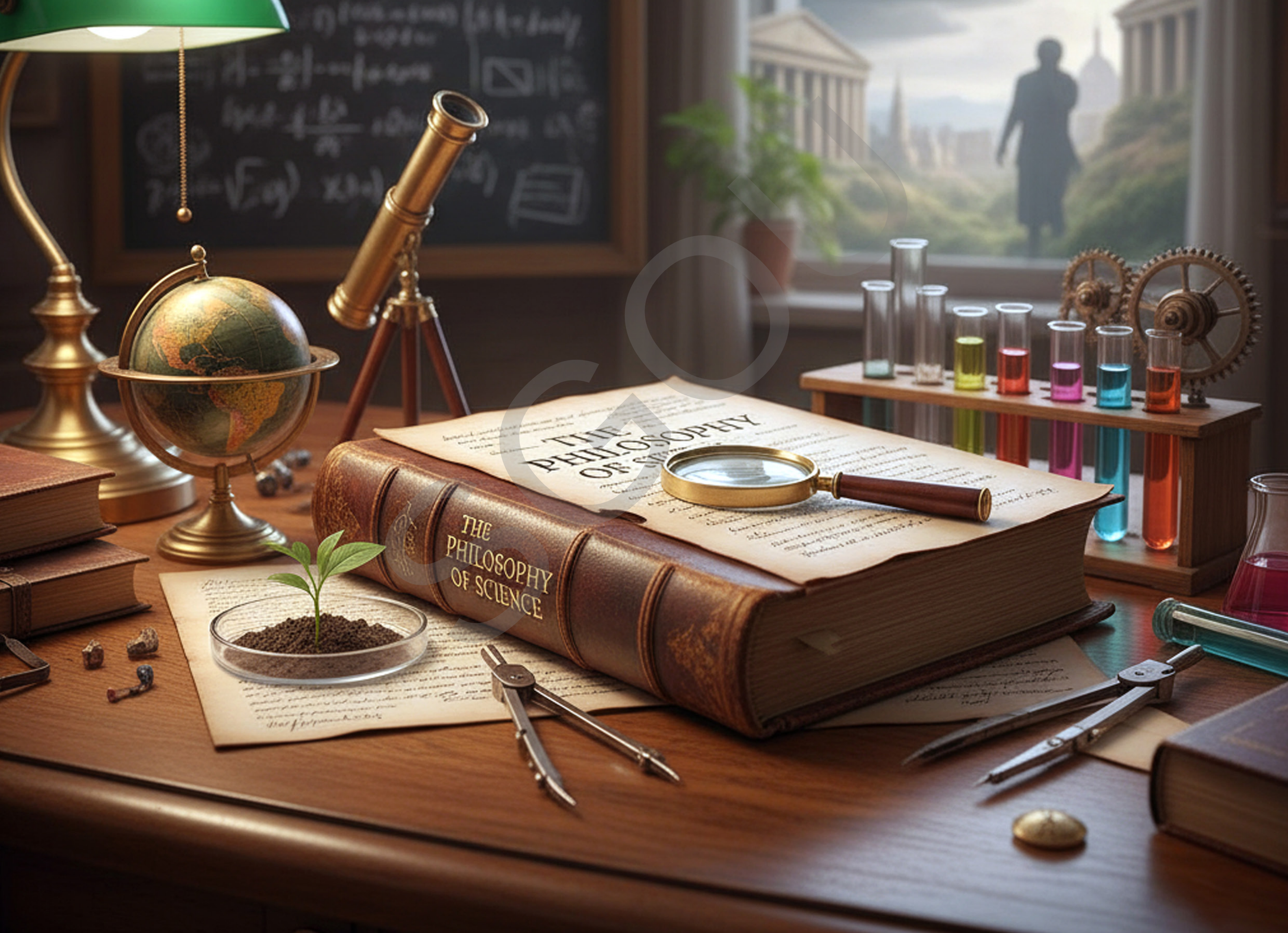
# Philosophy of Science

COURSE CODE: M23PH11DC
Discipline Core Course
Postgraduate Programme in Philosophy
Self Learning Material



SREENARAYANAGURU OPEN UNIVERSITY

The State University for Education, Training and Research in Blended Format, Kerala

# SREENARAYANAGURU OPEN UNIVERSITY



## Vision

*To increase access of potential learners of all categories to higher education, research and training, and ensure equity through delivery of high quality processes and outcomes fostering inclusive educational empowerment for social advancement.*

## Mission

To be benchmarked as a model for conservation and dissemination of knowledge and skill on blended and virtual mode in education, training and research for normal, continuing, and adult learners.

## Pathway

Access and Quality define Equity.

# Philosophy of Science

Course Code: M23PH11DC

Semester - IV

## Discipline Core Course
## Postgraduate Programme in Philosophy
## Self Learning Material



SREENARAYANAGURU OPEN UNIVERSITY

The State University for Education, Training and Research in Blended Format, Kerala

# PHILOSOPHY OF SCIENCE

Course Code: M23PH11DC
Semester- IV
Discipline Core Course
Postgraduate Programme in Philosophy

SREENARAYANAGURU
OPEN UNIVERSITY


**Academic Committee**

Prof. Abey Koshy
Dr.Sirajull Muneer
Dr Sairam R.
Dr. Gasper K. J.
Dr. R. Lakshmi
Dr. Biju K. P.
Dr. Soumya R.V.
Chandrababu M.

**Development of the Content**

Feleena C.L.
Dr Nisar A.C.

**Review and Edit**

Dr. L. Vijai

**Linguistics**

Sujith Mohan

**Scrutiny**

Dr Nisar A.C.
Feleena C.L.
Dr. Vijay Francis
Dr. Robin Luke Varghese
Dr. Deepa P.

**Design Control**

Azeem Babu T.A.

**Cover Design**

Jobin J.

**Co-ordination**

**Director, MDDC :**
Dr. I.G. Shibi
**Asst. Director, MDDC :**
Dr. Sajeevkumar G.
**Coordinator, Development:**
Dr. Anfal M.
**Coordinator, Distribution:**
Dr. Sanitha K.K.


Scan this QR Code for reading the SLM on a digital device.


**Edition**
September 2025





ISBN 978-81-990500-9-9




www.sgou.ac.m

Visit and Subscribe our Social Media Platforms

# MESSAGE FROM VICE CHANCELLOR

Dear learner,

I extend my heartfelt greetings and profound enthusiasm as I warmly welcome you to Sreenarayanaguru Open University. Established in September 2020 as a state-led endeavour to promote higher education through open and distance learning modes, our institution was shaped by the guiding principle that access and quality are the cornerstones of equity. We have firmly resolved to uphold the highest standards of education, setting the benchmark and charting the course.

The courses offered by the Sreenarayanaguru Open University aim to strike a quality balance, ensuring students are equipped for both personal growth and professional excellence. The University embraces the widely acclaimed "blended format," a practical framework that harmoniously integrates Self-Learning Materials, Classroom Counseling, and Virtual modes, fostering a dynamic and enriching experience for both learners and instructors.

The University aims to offer you an engaging and thought-provoking educational journey. The postgraduate programme in Philosophy is designed to be a continuation of the undergraduate programme in Philosophy. It maintains a close connection with the content and teaching methods of the undergraduate programme. It advances the more nuanced aspects of philosophical theories and practices. The university has recognised that empirical methods have limitations when explaining philosophical concepts. As a result, they have made a deliberate effort to use illustrative methods throughout their content delivery. The Self-Learning Material has been meticulously crafted, incorporating relevant examples to facilitate better comprehension.

Rest assured, the university's student support services will be at your disposal throughout your academic journey, readily available to address any concerns or grievances you may encounter. We encourage you to reach out to us freely regarding any matter about your academic programme. It is our sincere wish that you achieve the utmost success.

Warm regards.
Dr. Jagathy Raj V. P. 01-09-2025

# Contents

# BLOCK 1
# General Introduction

# UNIT 1
# Introduction to Philosophy of Science

## Learning Outcomes

Upon the completion of this unit, the learner will be able to:

- recognize the fundamental features of science, including observation, experimentation, and reasoning
- explain the philosophy of science and its significance in deepening our explaining of scientific knowledge and methods
- describe the nature and scope of the philosophy of science
- trace the historical development of science through the key contributions of Copernicus, Kepler, Galileo, Newton, and Einstein
- explain the significance of the Copernican Revolution and its impact on scientific thought
- evaluate Galileo's contributions to the scientific method, including his use of observation and experimentation



## Background

Science plays a vital role in our everyday lives. It helps us explain nature, make decisions, and solve problems. It is common to believe that scientific knowledge is always accurate, rational, and unchanging. But is that really true? Before assuming so, we must first ask: What is science? Is scientific knowledge always reliable? Is it something static and fixed? To explore these questions, we turn to the philosophy of science, a branch of philosophy that examines how science operates, how scientific knowledge is constructed, and what distinguishes scientific thinking. It helps us understand the strengths and limitations of science and how it influences our perspective on the world. Science has developed through a long process of trial and error. Scientists observe, experiment, make mistakes, and develop new theories from those experiences. Scientific knowledge is not static; it grows, changes, and improves over time. What we believe today may be revised tomorrow as new evidence emerges. To truly appreciate science, it is helpful to look at its development through history. Great thinkers such as Copernicus, Kepler, Galileo, Newton, and Einstein have changed the way we explain the universe. Each one built upon the work of others, often challenging accepted views and opening new ways of thinking. Science is not just a body of facts, but a living, evolving way of knowing the world. This understanding fosters curiosity, critical thinking, and a deeper respect for scientific inquiry.

## Keywords

Copernican Revolution, Heliocentric Model, Geocentric Model, Elliptical Orbit, Universal Gravitation, Relativity Theory

## Discussion

### 1.1.1 What is Science?

Science is a systematic way of explaining the natural world. It involves careful observation, logical reasoning, experimentation, and the development of theories to explain various phenomena. It is 'the method' that makes science different from other forms of knowledge. Scientists do not merely guess or depend on tradition; they verify their ideas through repeated experiments and observations. Scientific knowledge is constructed step by step, and over time, this process has led to what we now refer to as modern science. Modern science developed through many stages. Initially, science was closely connected to philosophy. Great thinkers such as Aristotle asked questions about nature, motion, and the causes of things.

- Science is a systematic, evidence-based method that builds reliable knowledge of the natural world

Later, during the Scientific Revolution in Europe, figures such as Galileo and Newton introduced new scientific methods. They stressed the importance of mathematics, measurement, and repeatable experiments. These changes marked the beginning of modern science, where ideas are carefully tested and knowledge is open to modification. One important feature of science is that it is always open to being questioned. No scientific idea is final. If new evidence appears, scientists must change their theories. This openness to correction makes science a powerful tool. However, this also leads to more profound philosophical questions. For example, how do we

- Science is always open to being questioned know that scientific methods are reliable? Why do we believe that a pattern we observe today will continue to produce the same result tomorrow? These are not questions that science alone can answer; they require philosophical reflection.

- Some philosophers have attempted to address the problem of induction by employing the concept of probability

Philosophers like David Hume have pointed out that science often relies on inductive reasoning, which involves drawing general conclusions from a limited or particular number of observations. However, just because something has always happened in the past, how can we be sure it will continue to happen in the future? This is known as the problem of induction. Some philosophers have attempted to address this issue by employing the concept of probability. In contrast, others, such as Karl Popper, have argued that science should focus not on proving theories but on attempting to disprove them. According to Popper, a scientific theory must be testable and open to being proven wrong. If a theory can never be shown false, then it is not truly scientific.

- Scientific knowledge changes as new discoveries are made

This brings us to the crucial distinction between science and pseudoscience. While science is based on evidence, open criticism, and testing, pseudoscience often lacks these features. Pseudoscientific claims may sound scientific, but they do not follow scientific methods. They may rely on personal beliefs, ignore contradictory evidence, or refuse to change in the face of new facts. The difference is not always easy to spot, but it is vital because pseudoscience can mislead people and create false impressions of truth. Science is not just a collection of facts; it is also a human activity that develops over time. Scientific knowledge changes as new discoveries are made. Sometimes, the basic framework of science itself shifts. Philosopher Thomas Kuhn referred to this as a paradigm shift. He demonstrated that science does not always progress in a linear manner; when a new idea replaces an old one, the entire way of thinking changes.

## 1.1.2 Philosophy of Science

The philosophy of science aims to investigate how science operates and what makes scientific knowledge trustworthy or limited. It attempts to explain how scientists construct theories, conduct experiments, and explain the world. Although the philosophy of science has become a relatively recent development as a separate discipline, the roots of such thinking date back to ancient times when philosophers first began to ask how we know what we know. As science became more detailed and specialised, the need to reflect on its assumptions, logic, and aims also increased. This reflection became an essential part of

- The philosophy of science examines how science works and the trustworthiness of its knowledge

philosophy. Science is known for employing methods such as observation and experimentation. But not all questions about knowledge and truth can be answered with experiments. For example, how do we decide whether a scientific explanation is correct? Can everything be measured? These more profound questions fall under the area of the philosophy of science. It attempts to clarify what it means to explain something scientifically and whether such explanations truly reveal how the world works. It also examines how scientific ideas evolve and whether they are merely useful tools or reflections of actual reality.

- Positivism focused on what could be observed and measured

Historically, many sciences, including physics and biology, originated within the realm of philosophy. Even today, when scientists define concepts like space or causality, they are working with ideas that have a philosophical background. Science and philosophy are closely connected, as science explains how things happen, while philosophy helps us reflect on what those explanations mean and whether they are sufficient. Philosophy also explores what constitutes knowledge, how we determine something is accurate, and how scientific ideas influence human life. Different ways of explaining science have developed over time. Romanticism once viewed science as an expression of human inner life and imagination, but it lacked the emphasis on testing and evidence that modern science values. In contrast, positivism focused strictly on what could be observed and measured. This provided science with a strong foundation in observation but overlooked the creative aspect of how theories are developed. Pragmatism offered a more flexible view by suggesting that scientific ideas should be judged by how well they work in practice. This view allowed space for change, uncertainty, and the idea that scientific knowledge grows over time.

- Philosophy of science examines the methods, evolution, and societal influences of science

In more recent times, technology and computer models have added new ways to explain how science works. The computational philosophy of science employs simulations to investigate how scientists think and solve problems. These tools do not replace philosophical thinking, but they help clarify how ideas evolve and how discoveries occur. The philosophy of science also looks at the broader role of science in society. It examines how cultural values, politics, and social concerns influence both what is studied and how scientific knowledge is applied. For instance, questions about climate change or medical ethics require both scientific facts and philosophical thought. Through this lens, science is not just a list of facts but a human activity shaped by goals, values, and debates. Studying the philosophy of science reveals that science is not perfect or complete; it evolves, makes mistakes, and relies on human judgement. It helps us think carefully about how we use science and how it helps us explain both the world and ourselves.

### 1.1.3 The Nature and Scope of Philosophy of Science

The philosophy of science is a branch of philosophy that carefully examines how science works, what constitutes scientific knowledge, and how scientific reasoning operates. It aims to explain not just the results of science, but the methods and assumptions behind them. Unlike science, which seeks to explain natural phenomena, the philosophy of science reflects on how those explanations are formed and what makes them reliable or questionable. It looks beyond surface-level explanations and raises more profound questions that scientists themselves may not always consider. One primary concern in the philosophy of science is the method of reasoning used in scientific practice. Science often relies on inductive reasoning, which involves drawing general conclusions from specific examples. For instance, if many observed pieces of metal conduct electricity, scientists might conclude that all metals conduct electricity. However, the philosopher David Hume challenged this assumption. He argued that just because something has happened in the past, we cannot logically be sure it will happen again.

- Science often relies on inductive reasoning, which involves drawing general conclusions from specific examples

Our belief in induction is based on habit rather than logical necessity. This poses a significant problem, as much of scientific knowledge depends on inductive reasoning. To address this issue, some philosophers turned to the idea of probability. Even if we cannot be sure about future events, we can assess their likelihood based on experience. In modern science, particularly in fields like physics and biology, many theories and laws are expressed in probabilistic terms. This approach does not entirely resolve Hume's problem, but it offers a more flexible way of addressing uncertainty in scientific reasoning. Another influential thinker, Karl Popper, took a different approach. He argued that science should not focus on confirming theories through repeated observations. Instead, science should aim to test theories by trying to falsify them. According to Popper, no number of favourable results can ever fully prove a theory, but a single negative result can show it to be false. This view of science emphasises critical testing, revision, and openness to being wrong. It also highlights the tentative and evolving nature of scientific knowledge.

- For Popper, no amount of supporting evidence proves a theory, but one counterexample can falsify it

The philosophy of science also explores how scientific explanations work. Carl Hempel, a prominent philosopher, suggested that scientific explanations follow a logical structure. They begin with general laws and specific conditions, which then lead to the phenomenon being explained. This model illustrates how theories relate to facts and how reasoning is employed to make sense of observed events. The goal is not only to describe what happens, but also to explain why it happens. Another major issue discussed in the philosophy of science is the debate between realism and anti-realism. Realists believe that science attempts to describe the world as it truly is. Anti-realists, or instrumentalists, however, argue that science should not be concerned with unseen realities. Instead, they believe that scientific theories are tools to help us predict and explain observable events. For them, the usefulness of a theory is more important than whether it is true. This debate continues to shape our explanation of the purpose and meaning of scientific knowledge.

- Carl Hempel suggested that scientific explanations follow a logical structure

Scientific change is another area that the philosophy of science investigates. Science is not a fixed set of truths but a dynamic process that evolves. Thomas Kuhn, a key figure in this area, introduced the concept of paradigm shifts. He argued that science progresses not just by accumulating facts, but through revolutionary changes in the way scientists view the world. During periods of normal science, most scientists work within a shared framework or paradigm. But eventually, problems arise that the current paradigm cannot solve. This leads to a scientific revolution and the adoption of a new paradigm. Kuhn also emphasised that scientific progress is influenced by social and historical factors, in addition to evidence and logic.

- Thomas Kuhn introduced the concept of paradigm shifts

The connection between philosophy and science has deep roots. Many scientific disciplines, such as physics, psychology, and computer science, began as branches of philosophy. As these fields developed and became more specialised, they separated from philosophy, but they still rely on philosophical concepts. For example, mathematics uses numbers but does not explain what a number is. Physics deals with time, but it does not fully define what time means. These are questions that science depends on but cannot answer through its methods. Philosophy continues to explore these foundational issues. Both science and philosophy use logical reasoning, including deduction and induction. However, philosophy also poses broader questions about values, ethics, and meaning; questions that science alone cannot answer. While science explains how

- Philosophy poses broader questions about values, ethics, and meaning; questions that science alone cannot answer things happen, philosophy considers why they matter. In this way, the philosophy of science does not compete with science but complements it. It clarifies the assumptions, methods, and goals of scientific inquiry, helping us think more deeply about the role science plays in human life.

## 1.1.4 Historical Development of Science - Views of Copernicus, Kepler, Galileo, Newton, and Einstein

**a. Copernicus**

- Copernicus challenged the Church-supported geocentric model with his heliocentric theory

Nicolaus Copernicus, a 16th-century Polish astronomer, played a pivotal role in the early development of modern science through his revolutionary heliocentric model of the universe. Until Copernicus, the widely accepted view was the geocentric model proposed by Ptolemy. The geocentric view held that the Earth was the centre of the universe and all heavenly bodies orbited it in perfect circles. This model was deeply tied to the teachings of Aristotle. Aristotle believed that the Earth was static and located at the centre of the universe. He also thought that all heavenly bodies (like the sun, moon, and stars) were perfect and moved in circular paths because circles were considered the most perfect shape. Both religious institutions and scholarly tradition supported this geocentric view. The Christian Church accepted and taught the geocentric model because it seemed to align with specific passages in the Bible and with the idea that God created Earth as the centre of creation. Since religious authorities controlled education through universities and church institutions, this view was widely taught and defended.

- According to Copernicus, the Earth is not stationary but is constantly moving in two crucial ways

In 1543, Copernicus published his most important work, *De revolutionibus orbium coelestium* (On the Revolutions of the Celestial Spheres). In it, he proposed that the Sun, not the Earth, was at the centre of the universe. According to Copernicus, the Earth is not stationary but is constantly moving in two crucial ways: First, he said that the Earth rotates on its axis once every 24 hours. This means that the Earth spins like a spinner around an invisible line called its axis, which goes through the North and South Poles. This rotation explains why we experience day and night. Second, Copernicus said that the Earth revolves around the Sun once every year; in other words, it completes one full orbit of the Sun in about 365 days. This movement explains the seasons. As the Earth orbits the Sun, the tilt of its axis causes different parts of the Earth to receive varying amounts of sunlight at various times of the year, resulting in changes in weather and daylight length.

Copernicus's heliocentric model was radical and challenged the deeply rooted geocentric view. He maintained the idea of circular orbits and used epicycles in his models, which made his system almost as complex as Ptolemy's. He did not fully break away from the Aristotelian tradition, and because his system lacked accurate predictions and supporting physical explanations, it was not immediately accepted. Nonetheless, his heliocentric model represented a significant intellectual shift. It questioned long-standing beliefs and laid the groundwork for future scientists to refine and develop a more accurate explanation of the cosmos. Copernicus's work faced skepticism because it contradicted common sense and observable experiences, such as the apparent stability of the Earth and the absence of strong winds or objects flying off the planet's surface, which people believed would occur if the Earth were moving. Furthermore, there were no physical laws at the time to explain how a moving Earth could be consistent with everyday experience. The shift from an Earth-centered to a sun-centered cosmos represents one of the most foundational changes in the Scientific Revolution. Although his model was not perfect, Copernicus's bold challenge to the traditional worldview marked the beginning of the Copernican Revolution, establishing him as a key figure in the history of science.

- The shift from an Earth-centered to a sun-centered cosmos represents one of the most foundational changes in the Scientific Revolution

**b. Kepler**

Johannes Kepler, a German mathematician and astronomer of the early 17th century, made significant contributions to the Scientific Revolution by building upon the heliocentric ideas of Copernicus. Unlike Copernicus, who retained circular orbits, Kepler demonstrated that the planets move in elliptical orbits, an oval-shaped curve, around the sun. This breakthrough came from his careful analysis of the astronomical observations collected by Tycho Brahe, one of the most accurate observers before the invention of the telescope. Tycho Brahe built large instruments to measure the positions of stars and planets with great precision. His records of planetary movements, especially of Mars, were the most accurate observations available at the time. Kepler used Tycho's high-quality measurements to analyse how planets moved in the sky. Through long and careful study of this data, Kepler realised that the old idea of planets moving in perfect circles did not match what Tycho had observed. This led him to discover that the planets move in elliptical orbits, which became the basis of his three laws of planetary motion.

- Kepler demonstrated that the planets move in elliptical paths

The first law states that planets orbit the Sun in ellipses, not perfect circles, with the Sun at one focus. Kepler's second law of planetary motion, called the law of equal areas, describes how a planet's speed changes as it moves around the sun. It states that a planet covers the same area in the same amount of time as it orbits the sun. This means the planet moves faster when it is closer to the sun and slower when it is farther away, so a planet's speed changes during its orbit depending on its distance from the sun. The third law explains the relationship between a planet's distance from the sun and the time it takes to complete one orbit. It states that planets farther from the sun take longer to orbit than those closer to the sun, and this time increases in a regular mathematical manner. These laws were significant because they provided a simple and mathematically accurate description of planetary motion. Kepler showed that the motion of celestial bodies could be described without the need for complex systems of circles and epicycles. His work revealed that the heavens operate according to the same physical principles as Earth, laying the groundwork for Isaac Newton's theory of universal gravitation.

- Kepler's second law of planetary motion describes how a planet's speed changes as it moves around the sun

Kepler's approach to science also illustrated a shift from relying on ancient authority to trusting careful observation and mathematical reasoning. His readiness to abandon the idea of circular orbits, which had been considered a symbol of perfection, demonstrated a break from traditional beliefs and a movement toward empirical science. While Kepler himself did not fully explain the forces that caused planetary motion, his laws were crucial in establishing that the universe followed mathematical rules. This concept became central to modern science. Kepler's contributions highlight the importance of accurate data, mathematical analysis, and the courage to challenge established ideas. He demonstrated that scientific progress often entails revising previous models and being receptive to new patterns that emerge from observation.

- Kepler's contributions highlight the importance of accurate data, mathematical analysis, and the courage to challenge established ideas

**c. Galileo**

Galileo Galilei, an Italian physicist and astronomer of the late 16th and early 17th centuries, played a crucial role in shaping the modern scientific method. He is often regarded as the father of modern science because he was among the first to systematically combine observation, experimentation, and mathematics to investigate natural phenomena. Galileo challenged long-standing Aristotelian views on motion and the heavens, laying the groundwork for the laws of mechanics. One of his key contributions was his study of motion. He discovered

- Galileo discovered that objects in free fall accelerate uniformly, regardless of their mass that objects in free fall accelerate uniformly, regardless of their mass. This finding contradicted Aristotle's belief that heavier objects fall faster than lighter ones.

- Galileo introduced the concept of inertia, showing that an object in motion will remain in motion

Galileo also studied projectile motion and concluded that the path of a projectile is a parabola. He introduced the concept of inertia, showing that an object in motion will remain in motion unless acted upon by an external force. These insights laid the groundwork for Newton's later work. Galileo's use of the telescope revolutionised astronomy. Although he did not invent the telescope, he significantly improved it and used it to make several important discoveries. He observed the rough surface of the moon, proving it was not a perfect sphere, as Aristotle had claimed. He discovered four moons orbiting Jupiter, which challenged the idea that all celestial bodies revolved around the Earth. He also observed the phases of Venus, which supported the Copernican heliocentric model.

- Galileo demonstrated that knowledge about the natural world should be based on empirical evidence and logical reasoning

Despite his scientific achievements, Galileo faced strong opposition from the Catholic Church, which supported the geocentric view. His open support of the Copernican model led to a trial by the Inquisition, and he was forced to withdraw his views and spent the rest of his life under house arrest. Nevertheless, his work had a lasting impact. Galileo demonstrated that knowledge about the natural world should be based on empirical evidence and logical reasoning, not tradition or authority. His emphasis on observation and experimentation marked a turning point in the history of science. He showed that nature could be understood through precise measurement and mathematical description, leading to a more systematic and reliable way of gaining knowledge. His bold questioning of established beliefs and his use of new instruments made him a symbol of the scientific revolution and an incredible figure in the history of science.

**d. Newton**

- Newton's three laws of motion explained how objects move and interact

Isaac Newton, a towering figure of the 17th century, transformed science with a unified theory that explained both the motion of objects on Earth and the movements of celestial bodies. He synthesised the discoveries of Copernicus, Kepler, and Galileo into a unified, coherent framework. His most famous work, *Philosophiae Naturalis Principia Mathematica*, published in 1687, laid down the laws of motion and the universal law of gravitation. Newton's three laws of motion explained how objects move and interact. The first law, the law of inertia, states that an object in motion remains in motion, and an object at rest will stay at rest with the same speed and direction unless acted upon by an external force.

The second law quantified how the force applied to an object affects its acceleration. It states that the acceleration of the body is directly proportional to the force acting on it and inversely proportional to the mass of the body. The third law states that for every action, there is an equal and opposite reaction. Together, these laws provided a powerful mathematical explanation of motion. Newton's law of universal gravitation proposed that every object in the universe attracts every other object with a force that is proportional to the product of their masses and inversely proportional to the square of the distance between them. This law explained the orbits of planets, the motion of the moon, and even the fall of an apple to the ground. Newton demonstrated that the same physical laws govern both the heavens and Earth, a revolutionary concept.

- Newton's law of universal gravitation proposed that every object in the universe attracts every other object with a force

In addition to his work in physics, Newton made significant contributions to mathematics, including the development of calculus, which provided the tools needed to describe motion and change precisely. His methods and reasoning significantly influenced the development of the scientific method and were widely admired and adopted. Newton's vision of the universe was mechanistic. He imagined the cosmos as a great machine operating according to fixed laws, which could be described with precision and certainty. This view dominated science for over two centuries and formed the foundation of classical physics. Although later developments in science, especially in the 20th century, revealed the limits of Newtonian physics, his influence remains immense. His work represents the scientific revolution and serves as a model of scientific achievement that continues to inspire.

- Newton imagined the cosmos as a great machine operating according to fixed laws, which could be described with precision and certainty

**e. Einstein**

Albert Einstein, one of the most influential scientists of the 20th century, profoundly changed our understanding of space, time, and gravity. His theories addressed the limitations of Newtonian physics and introduced new ways of thinking about the universe. Einstein's most famous contribution is the theory of relativity, which consists of two parts: special relativity and general relativity. In 1905, Einstein published the 'Special Theory of Relativity', which demonstrated that the laws of physics are the same for all observers moving at constant speeds and that the speed of light is constant in all frames of reference. One of its key insights is that time and space are not absolute;

- Einstein's most famous contribution is the theory of relativity they depend on the motion of the observer. This theory also introduced the famous equation $E = mc^2$, which demonstrates that mass and energy are interchangeable.

- General relativity redefined gravity as the curvature of space-time caused by mass

A decade later, in 1915, Einstein introduced the 'General Theory of Relativity', which redefined the concept of gravity. Instead of viewing gravity as a force between masses, he proposed that massive objects cause a curvature in space-time, and this curvature affects the motion of objects. The predictions of general relativity were confirmed during a solar eclipse in 1919, when starlight was observed to bend around the sun, just as Einstein had predicted. Einstein's theories not only explained phenomena that Newton's laws could not, such as the orbit of Mercury, but also paved the way for modern cosmology, including the explanation of black holes, the expansion of the universe, and the Big Bang theory. His ideas laid the groundwork for much of modern physics.

- Einstein's work showed that science is not static but constantly evolving

Einstein was also profoundly philosophical and often reflected on the meaning of scientific inquiry. He believed in the power of reason, imagination, and simplicity in uncovering the truths of nature. Although some of his later works, especially his attempts to unify all forces of nature, remained unfinished, his legacy serves as a testament to his scientific brilliance and creativity. Einstein's work showed that science is not static but constantly evolving. He taught us that questioning established ideas and exploring new paths can lead to insightful discoveries. His impact extends far beyond physics, influencing philosophy, technology, and our understanding of the universe.



## Summarized Overview

The philosophy of science is a branch of philosophy that examines the nature of science, what constitutes scientific knowledge, and how scientific theories are developed and justified. It poses crucial questions, such as: What is science? How do scientists arrive at the truth? Can we fully trust scientific knowledge? It examines the methods scientists use, such as observation, experimentation, and reasoning, and assesses whether these methods are reliable and effective. It also examines how scientific theories evolve over time and whether science provides a comprehensive explanation of reality. The scope of the philosophy of science encompasses the examination of the logic underlying scientific explanations, the limitations of scientific knowledge, and the influence of values, culture, and society on shaping scientific practice. By doing so, it helps to better explain the strengths and limits of science in explaining the natural world.

The history of science explains how our understanding of the universe changed over time through the ideas of major scientists. Copernicus was the first to challenge the belief that the Earth is at the centre of the universe. He proposed that the Sun is at the centre and that the Earth moves around it. Kepler improved this idea by demonstrating that planets orbit in elliptical, not circular, paths. Galileo supported these views with the aid of a telescope and showed that the traditional beliefs about the sky were incorrect. He also studied motion and found that all objects fall at the same rate regardless of their weight. These scientists used careful observation and mathematics to explain nature better and to question old ideas. Newton brought these ideas together with his laws of motion and gravity. He showed that the same rules apply both in the sky and on Earth. His view of the universe was akin to a machine operating under fixed laws. Later, Einstein showed that time and space are not fixed but change depending on movement. His theory of relativity explained new phenomena, such as the bending of light and the relationship between energy and mass. Together, these scientists transformed the way we perceive the universe, demonstrating that science advances through the process of asking questions, gathering evidence, and remaining open to new ideas.

## Self-Assessment

1. What are the primary concerns addressed by the philosophy of science?
2. Make a note on the nature and scope of the philosophy of science.
3. What central idea did Copernicus propose in his heliocentric model, and how did it challenge traditional views?
4. In what ways did Galileo's use of the telescope and his experiments change the understanding of motion and the structure of the universe?
5. How did Einstein's theory of relativity revise Newton's concept of gravity and contribute to modern physics?
6. What are the main questions that the philosophy of science seeks to answer about scientific knowledge and methods?

## Assignments

1. Make a note on science, and explain how the philosophy of science differs from it. Discuss how the philosophy of science explores the foundations, methods, and goals of scientific inquiry.
2. Compare the contributions of Copernicus and Galileo to the Scientific Revolution and explain how their ideas challenged traditional beliefs.
3. Trace the historical development of scientific thought by examining the key contributions of Copernicus, Kepler, Galileo, Newton, and Einstein. How did their discoveries challenge traditional beliefs and shape the foundations of modern science?

## Reference


1. Kuhn, T. S. (1962). *The Structure of Scientific Revolutions*. University of Chicago Press.
2. Okasha, S. (2002). *Philosophy of Science: A Very Short Introduction*. Oxford University Press.
3. Chalmers, A. F. (1999). *What Is This Thing Called Science?* An Assessment of the Nature and Status of Science and Its Methods (3rd ed.). Hackett Publishing Company.
4. Popper, K. (2002). *The Logic of Scientific Discovery* (2nd ed.). Routledge Publications.
5. Van Fraassen, B. C. (1980). *The Scientific Image*. Oxford University Press.
6. Godfrey-Smith, P. (2013). *On the Relation Between Philosophy and Science*. Paper presented at the First Gesellschaft für Wissenschaftsphilosophie Conference, Hannover, Germany.


## Suggested Reading


1. Copernicus, N. (1543). *De Revolutionibus Orbium Coelestium* [On the Revolutions of the Heavenly Spheres]. Johannes Petreius.
2. Skinner, B. F. (1953). *Science and Human Behaviour*. Macmillan.
3. Butterfield, H. (1957). *Man on His Past*. Cambridge University Press.
4. Heilbron, J. L. (2010). *Galileo*. Oxford University Press.

## Space for Learner Engagement for Objective Questions

Learners are encouraged to develop objective questions based on the content in the paragraph as a sign of their comprehension of the content. The Learners may reflect on the recap bullets and relate their understanding with the narrative in order to frame objective questions from the given text. The University expects that 1 - 2 questions are developed for each paragraph. The space given below can be used for listing the questions.

# UNIT 2
# Scientific Realism vs Scientific Anti-Realism

## Learning Outcomes

Upon the completion of this unit, the learner will be able to:

- explain the fundamental relationship between philosophy and science
- differentiate between scientific realism and scientific anti-realism, including their key concepts
- describe how philosophical reasoning supports scientific thinking
- explain the role of metaphysical and epistemological questions in shaping scientific theories and their interpretation
- critically examine the key objections raised against scientific realism and scientific anti-realism

## Background

One of the most relevant questions in philosophy is whether the world exists independently of our thoughts, perceptions, and experiences. Philosophers have explored this question in various ways since ancient times. In the Western tradition, thinkers such as George Berkeley have questioned whether objects continue to exist if no one is observing them. This inquiry into the nature of reality—whether it exists 'out there' independently or is dependent on the perceiver—lies at the heart of many philosophical debates. As human explanation developed, science emerged as a powerful tool for understanding the world. Through observation, experimentation, and logical reasoning, science has enabled us to uncover patterns and explain natural phenomena. However, science also raises more profound philosophical questions. For instance, when scientists discuss phenomena that cannot be directly observed, such as electrons, atoms, or gravitational force, should we consider these as real, existing entities? Or are they just theoretical concepts that help us explain what we observe?

These questions lead to a key debate in the philosophy of science between scientific realism and scientific anti-realism. These two viewpoints offer different answers to the question: What is science doing? Is it discovering objective truths about an independent reality? Or is it simply constructing models that are useful, without necessarily revealing the world's true nature? Here, the debate is explored by examining the assumptions underlying scientific knowledge, such as what constitutes truth, what is meant by 'reality,' and what limits human knowledge may impose. Understanding this helps to see how deeply connected philosophy and science are, and why exploring these questions is essential to making sense of both scientific practice and philosophical inquiry today.

## Keywords

Scientific realism, Scientific anti-realism, Instrumentalism, Fictionalism, No-miracles argument, Pessimistic meta-induction, Underdetermination, Entity realism, Structural realism, Partial realism

## Discussion

### 1.2.1 The Relation Between Philosophy and Science

- Philosophy and science are closely connected, with science emerging from philosophy

Philosophy and science are closely intertwined, even though they are often viewed as distinct fields of study. Both aim to deepen our understanding of the world, but they do so in different ways. Science seeks to explain natural phenomena through observation, experimentation, and the formulation of laws. Philosophy, on the other hand, explores more profound questions—questions about the nature of knowledge, existence, values, logic, and meaning—that often go beyond what science alone can address. Historically, many sciences grew out of philosophy. Physics was once known as 'natural philosophy.' Psychology and biology were once integral to philosophical discussions before evolving into independent fields. For example, Galileo and Newton helped shape physics as a separate science, while Darwin's theory of evolution marked biology's departure from philosophy. Even today, disciplines such as computer science owe a great deal to philosophical areas, including logic.

Despite their separation, science still leaves many fundamental questions for philosophy to address. For example, mathematics works with numbers, but it cannot answer the question 'What is a number?' Similarly, physics uses the concept of time but does not fully explain what time is. These deep conceptual issues remain the concern of philosophy. Philosophy also plays a vital role in examining the methods of science. Scientific reasoning relies heavily on logic, both deductive and inductive; however, philosophy studies why these methods are reliable and where they might fall short. This makes philosophy essential to explaining the strengths and limits of science itself. While science is primarily descriptive, telling us how things are, philosophy often asks normative questions, such as what we ought to do or what is morally right. These are questions science does not aim to answer. Ethics, political philosophy, and aesthetics are areas where philosophical inquiry goes far beyond the scope of scientific investigation.

- Philosophy plays a vital role in examining the methods of science

Philosophycan also serve as a kind of incubator for ideas. It provides a space for thinking about broad concepts and possibilities that may later be developed into scientific theories. For example, early ideas in the philosophy of mind eventually influenced psychology and cognitive science. Concepts such as causation, time, consciousness, and probability often originate as philosophical ideas before being refined through scientific investigation. Furthermore, philosophy plays an integrative role, helping us bring together knowledge from different scientific fields and connect it to broader human concerns. It looks at how different parts of our understanding 'hang together,' as philosopher Wilfrid Sellars once said. This makes philosophy important in creating a big-picture understanding of the world and our place in it.

- Philosophy inspires science and connects knowledge for a deeper explaining of the world

Some scientists have criticised philosophy for being too abstract or outdated. However, many scientific breakthroughs have been guided by philosophical thinking. For instance, Einstein was influenced by earlier philosophical debates about space and geometry. The development of logic and mathematics through thinkers like Frege and Russell also contributed to the rise of computer science. In modern times, both science and philosophy continue to benefit from each other. Philosophers question assumptions, clarify concepts, and explore ethical implications. Scientists provide new data and methods that philosophers use to refine their ideas. Together, they help build a more complete and thoughtful understanding of the world. Philosophy and science are distinct but complementary. Science explains how things work, while philosophy asks what those explanations mean, how we know them, and what we

- Science explains how things work; philosophy explores their meaning and value should do with that knowledge. They share tools like logic and critical thinking, and both aim to explore truth, just from different angles. Their partnership remains essential for human understanding and progress.

## 1.2.2 Scientific Realism

- Scientific realism claims that science reveals the objective reality of both seen and unseen entities

It is a common belief that the world exists independently of whether we observe it or not, known as common-sense realism. Building on this idea, scientific realism posits that both observable entities, such as rocks, plants, and animals, and unobservable entities like electrons, black holes, and genes, are real and exist independently of our minds. According to this view, the universe operates according to objective principles, regardless of human perception, and scientific theories aim to describe these principles as accurately as possible. Scientific realists view science as more than just a tool for organising data or making predictions; they see it as a means to uncover the actual structure and workings of the universe.

- Scientific realism sees the unobservable as real

Scientific realism holds that when scientists discuss unobservable entities, they are not employing imaginative stories or metaphors as a means of explanation. They are referring to real components of nature, whose consistent behaviour and ability to explain and predict outcomes give us strong reason to believe in their existence. Although certain entities may not be directly observable, their consistent effects, explanatory strength, and predictive power support their ontological status as real. However, not all philosophers agree with scientific realism. Anti-realists, including instrumentalists, challenge this view. They argue that we can never be certain if scientific theories truly describe reality because our knowledge is mediated through our senses, and sensory experience is inherently subjective. From the anti-realist point of view, the world we 'know' is shaped by how we interpret what we see, hear, or measure. Therefore, they see scientific theories not as literal truths, but as valuable tools or models that help us explain and predict observable events.

Philosophers generally identify three fundamental commitments that define scientific realism:

1. **Metaphysical Commitment:** This asserts that a reality exists independently of our thoughts, perceptions, or linguistic frameworks. It encompasses not only tangible objects, such as trees or rocks, but also intangible entities, including atoms or gravitational fields. As the cognitive scientist David Chalmers

notes, without this assumption, science would lose its aim of discovering truths about a world that is not entirely shaped by our mental constructs.

2. **Semantic Commitment:** Scientific theories should be taken literally; terms like 'electron' or 'gene' are intended to refer to actual entities in the world. Samir Okasha, in his text *Philosophy of Science: A Very Short Introduction*, emphasises that scientific language is not merely instrumental; it attempts to capture the structure of reality itself.

3. **Epistemic Commitment:** Scientific realism maintains that well-supported scientific theories are at least approximately true. This means that science progressively refines its explanations of the world, and changes in theory typically reflect more profound insights, not wholesale rejection of prior knowledge. The progression from Newtonian mechanics to Einstein's theory of relativity, for instance, illustrates how science retains core truths while improving explanatory scope.

- The success of science would be a miracle if our theories were not at least approximately true.

One of the most compelling arguments in favour of scientific realism is the 'no miracles' argument. The American philosopher and mathematician Hilary Putnam famously claimed that the success of science would be a miracle if our theories were not at least approximately true. The fact that scientific theories enable us to launch satellites, develop reliable medicines, and uncover deep cosmic phenomena strongly suggests that they are doing more than just organising data; they are grasping the structure of reality. Additionally, scientific realism is supported by the principle of inference to the best explanation. When competing theories explain the same phenomenon, the one that provides the most coherent and predictive account is typically regarded as closer to the truth. Darwin's theory of evolution by natural selection, for example, offers a unified explanation of biological diversity that has been supported by both fossil records and molecular biology.

A critical area in the realism debate concerns the status of unobservable entities. Realists argue that although we cannot observe electrons or DNA directly, the consistent success of theories involving such entities justifies belief in their existence. As Chalmers discusses, these entities are not theoretical conveniences but indispensable parts of models that generate testable predictions. Scientific realism also incorporates the idea of approximate truth. Scientific theories evolve, but this evolution is seen as a process of refinement. Newton's classical mechanics still provides accurate predictions for many everyday applications, even though it has been superseded by relativistic and quantum theories in other domains. This continuity suggests that new theories often build on the strengths of earlier ones, leading to a more accurate and comprehensive explanation of reality. Scientific realism offers a robust framework for explaining science as a rational and truth-seeking enterprise. Grounded in its metaphysical, semantic, and epistemic commitments, it affirms that science is capable of revealing the underlying nature of the universe, not with infallibility, but with increasing depth and reliability.

- Scientific theories change over time through refinement and improvement, and not complete rejection.

### 1.2.2.1 Criticisms of Scientific Realism and Realist Responses

One of the most potent criticisms of scientific realism is the pessimistic meta-induction. It points out that many scientific theories, once widely believed to be true, such as the geocentric model of the universe, were eventually abandoned. If past successful theories turned out to be wrong, why should we think that current theories are correct? Scientific realists acknowledge that older theories were eventually superseded, but they argue that this does not mean that science is inherently unreliable. Instead, they believe that science improves over time by building on and refining earlier theories. For example, Einstein's theory of relativity did not wholly reject Newton's laws; instead, it explained when Newton's laws are applicable and when they are not. This shows that science does not discard things entirely. It retains useful parts and gradually approaches the truth. Critics also argue that if scientific theories change over time, then our current theories may also prove to be incorrect in the future. This makes it hard to believe that we are getting any closer to the truth.

- Pessimistic meta-induction claims that past scientific errors suggest current theories may also be false

Scientific realists accept that theories evolve; this is a sign of progress. Even if a theory is not 100% true, it can still be approximately true. According to David Chalmers, theories are tools that work well in many situations. Over time, science becomes better at explaining and predicting phenomena, even if the perfect truth remains out of reach. Anti-realists question the belief in unobservable entities, such as electrons, quarks, or dark matter. They argue that we cannot see these things directly and only infer their existence through experiments or mathematical models. Scientific realists reply that unobservable

- Scientific realism trusts unobservable entities as real because they help science succeed entities are central to the success of science. Take genes, for instance. We cannot see genes with the naked eye, but their existence is confirmed through their effects on inheritance and physical traits. Patterns of genetic inheritance, observed through experiments with plants, animals, and humans, would not make sense without assuming that genes are real units of heredity. Their effects are consistent and measurable, which gives us strong reasons to believe they are real. Okasha emphasises that if these entities were not real, it would be hard to explain why science and technology work so well. Because of such criticisms, some philosophers have developed more flexible versions of realism. They are:

1. **Entity Realism**: Entity realism is the view that if we can use or manipulate something in experiments, we have good reason to believe it really exists. For instance, scientists cannot always see viruses directly with the naked eye, but they can grow viruses in the lab, inject them into cells, and study how they cause diseases. They can also create vaccines that target specific viruses. Since we can interact with viruses in experiments and produce real effects, entity realism says it is reasonable to believe that viruses are real.
2. **Structural Realism:** Structural realism is the idea that even if we do not fully explain what something truly is, we can still comprehend its structure, relationships, behaviour, and interactions with other entities, particularly through mathematical patterns. For instance, if we do not know everything about what the Sun or planets are composed of, we can still explain how they relate to each other and follow specific patterns. We see how the planets orbit the Sun, how gravity influences their motion, and how their positions can be accurately predicted using mathematical principles. Even if our explanations of what the Sun and space are composed of continue to evolve, the structure of the solar system, its patterns of movement, and its relationships remain consistent and reliable. Here, we can trust the scientific patterns and rules that describe how they move and interact.
3. **Partial Realism:** It suggests that not all parts of a theory are equally trustworthy. Some parts may refer to real entities, while others are speculative and could change. Partial realism suggests that we can trust the parts of a theory that are strongly supported by experiments. Still, we should exercise caution when considering parts that may change as science advances.

These versions show that realism is not a fixed doctrine. It can adapt and respond to new challenges while still maintaining the idea that science provides us with genuine knowledge about the world.

## 1.2.3 Scientific Anti-Realism

- Scientific anti-realism views theories as tools for predicting observables, not for revealing unobservable truths

Scientific anti-realism, also known as instrumentalism, presents a distinct perspective on science in contrast to scientific realism. While realists believe that science aims to describe the truth about both the visible and invisible parts of the world, anti-realists take a more cautious approach. Scientific anti-realism does not deny the usefulness or power of science but is sceptical about whether scientific theories accurately describe reality, especially when it comes to things that cannot be observed directly, such as electrons, atoms, or black holes. According to scientific anti-realism, the primary purpose of science is not to discover the ultimate truth but to create models and theories that help us explain and predict what we can observe in the world. From this perspective, science is most reliable when it deals with observable phenomena, such as trees, rivers, mountains, animals, or weather events, because these can be directly observed, measured, and confirmed. In such cases, realists and anti-realists often agree, as both accept that the findings are based on real, observable evidence.

- Scientific anti-realism treats the unobservable not as literal truths about reality

The distinction between realism and anti-realism becomes clearer when science encounters entities that are beyond direct observation. Anti-realists believe that unobservable things, such as electrons or gravitational waves, may not exist as described in scientific theories. Instead, they view these entities as useful concepts that help scientists make predictions or explain natural phenomena. Theories involving these unobservable entities are considered helpful tools rather than descriptions of what is genuinely out there. A notable example illustrating the anti-realist perspective is Newton's third law of motion, which states that for every action, there is an equal and opposite reaction. This law helps explain various physical interactions, such as the recoil of a gun or the propulsion of a rocket. While it accurately predicts how objects behave, anti-realists argue that the concept of 'force' involved in the law is neither directly observable nor an objectively existing entity. Instead, they consider 'force' to be a theoretical construct—an idea that aids the model rather than a real component of nature. From the anti-realist point of view, Newton's third law is valuable not because it reveals a hidden truth about invisible forces, but because it effectively predicts observable events.

Newton's third law of motion is seen as a tool that helps us describe and predict observable results without necessitating belief in the literal existence of the unobservable parts of the theory. Importantly, most modern scientific anti-realists do not claim that assertions about unobservable entities are false. Instead, they suggest that since human beings cannot directly access or observe these hidden aspects of the world, we cannot truly know whether such claims are true or false. In other words, anti-realists choose to remain agnostic; they neither fully believe nor entirely disbelieve in the reality of unobservable entities. They simply state that we have no way of being sure, and therefore, we should not treat scientific theories as accurate descriptions of reality but as useful instruments for explaining the world we can observe.

- Anti-realists stay agnostic about the reality of unobservables.

Anti-realists acknowledge that science is very effective in solving problems, predicting events, and organising our experiences. However, they remain sceptical about whether science truly reveals what the world is like at a deeper level, especially concerning unobservable phenomena. For them, the value of science lies in its ability to work, not necessarily in its capacity to reveal truth. Scientific theories are important because they help us make sense of the world we can experience. However, we should be cautious about trusting them too much when they extend beyond what we can see or test directly.

- Anti-realists see science as effective for prediction and problem-solving.



### 1.2.3.1 Criticism of Scientific Anti-Realism

Although scientific anti-realism encourages a careful and humble approach to science, it has also faced several criticisms. One of the most significant arguments against anti-realism is based on the idea that science has a long record of successful theories that accurately describe the world. Critics argue that it is unreasonable to think that all of this success is merely a coincidence. If scientific theories were merely useful tools, not grounded in reality, it would be surprising for them to consistently produce accurate predictions, lead to successful technologies, and explain natural phenomena so effectively. Another common criticism concerns the distinction anti-realists make between observable and unobservable entities. Realists argue that this distinction is not clear-cut. In modern science, we often use instruments such as microscopes, telescopes, or particle detectors to observe objects that are too small or too distant for the naked eye. For example, we cannot see cells or distant galaxies directly without the aid of tools, but we still accept them as real entities.

- Anti-realism is faulted for ignoring science's predictive success and its blurry observable–unobservable divide.

- Realists point out that science progresses not by throwing out old ideas entirely, but by improving and refining them.

If we trust instruments to show us cells and stars, realists ask why we should not also trust them to inform us about electrons or other unobservable entities. Drawing a strict line between what is observable and unobservable becomes difficult, and critics believe this weakens the anti-realist position. Another strong criticism comes from the realist response to the pessimistic meta-induction, an argument often used by anti-realists. This argument suggests that many past scientific theories were once believed to be true but were later rejected, implying that our current theories might also be incorrect. Realists respond by pointing out that science progresses not by discarding old ideas entirely, but by improving and refining them. For example, Newton's laws were not abandoned when Einstein introduced the theory of relativity. Rather, Newton's ideas are still used in many situations, and Einstein's theory helped explain when and why Newton's laws do not apply. This demonstrates that science can approach the truth more closely over time, even if it does not achieve complete truth all at once.

- Underdetermination shows multiple theories can fit the same evidence, challenging certainty about which is true.

Anti-realism is also questioned through the idea of underdetermination, which means that more than one theory can explain the same evidence. Anti-realists use this to argue that we cannot know which theory, if any, is true. For example, in the history of astronomy, both the geocentric model (where the Earth is at the centre of the universe) and the heliocentric model (where the Sun is at the centre) were once able to explain the observed motion of planets in the sky. For a time, both models were consistent with the available evidence. This led some to believe that we cannot be certain which theory is truly accurate. However, realists respond by saying that in real scientific practice, not all theories are equally good.

- Scientists use simplicity and explanatory power to choose between theories, strengthening realism.

Over time, scientists preferred the heliocentric model because it was simpler, more consistent with other scientific findings, and offered better explanations of planetary motion, especially after the work of Galileo and Kepler. This example demonstrates that even when multiple theories appear plausible, scientists can still employ logical criteria such as simplicity, accuracy, and explanatory power to determine which theory is more likely to be true. While scientific anti-realism reminds us to be careful about how far we trust scientific theories, it also faces important criticisms. These include the success and progress of science, the blurred line between observable and unobservable entities, and the idea that not all equally predictive theories are equally valid. As a result, the debate between realism and anti-realism remains central in the philosophy of science, helping us reflect on the nature and limits of scientific knowledge.

- Realists see science's goal as uncovering actual reality; anti-realists view it as building models that accurately predict observations.

The central debate between realists and anti-realists concerns the goal of science. Is science trying to tell us what the world is really like? Or is it simply trying to develop models that work well in practice? Realists argue that science aims at truth, even about things we cannot directly observe. At the same time, anti-realists believe the aim is merely to match theories with observations and predict outcomes. From their perspective, as long as a theory 'saves the phenomena' (i.e., accurately describes what we observe), that is enough. Theories, in this view, are convenient and valuable, but not necessarily true. One major issue in this debate is the difference between observable and unobservable entities. Scientific realists think we can make reliable claims about both. Anti-realists, on the other hand, believe we should be cautious about speaking as if unobservable things truly exist, because we cannot directly access or verify them.

- Science relies on observation and experience, whereas metaphysics often employs reasoning alone

This difference leads to more profound philosophical questions. Metaphysics asks what exists, while epistemology asks how we can know what exists. Science relies on observation and experience (empirical evidence), whereas metaphysics often employs reasoning alone. Some thinkers argue that science requires a metaphysical foundation to make sense of its subject matter, while others contend that metaphysics adds nothing meaningful to scientific knowledge. A powerful historical example of this tension is Galileo's conflict with the Church. Galileo believed the Earth orbits the Sun, a view based on his scientific observations. The Church accepted this model as a valuable tool for calculations but strongly rejected the idea that it could be literally true.

- Extreme anti-realist positions include fictionalism, which claims that truth is irrelevant in science

Some more extreme anti-realist positions include fictionalism, which claims that truth is irrelevant in science. From this perspective, scientific theories are merely helpful fictions that enable us to make predictions, rather than things we should unquestioningly accept as accurate. Ultimately, philosophers of science must strike a balance between two challenges: explaining the detailed and complex work conducted by scientists in specific fields and developing general philosophical theories about knowledge and truth. Some, such as William Whewell and Alexander Bird, describe this as a tension between particularism (focusing on specific scientific practices) and generalism (examining science from a broader philosophical perspective).

## Summarized Overview

Philosophy and science are closely intertwined in their search for knowledge. While science relies on observation and experiment, philosophy inquires more deeply into philosophical questions about what we know, how we know it, and what reality is. The relationship between the two becomes significant when considering whether scientific theories truly describe the world. Scientific realism is a substantial theory in the philosophy of science; it is the view that the world exists independently of our minds and that well-supported scientific theories reveal real features of both observable and unobservable entities, such as atoms, electrons, or black holes. In contrast, scientific anti-realism argues that we should not assume scientific theories are true. Instead, these theories should be seen as valuable tools for explaining and predicting what we observe, without making claims about what exists.

This debate introduces essential ideas, including metaphysical, semantic, and epistemic commitments, which define the realist position. It also presents major arguments, such as the no-miracles argument, which supports realism by arguing that the success of science in explaining and predicting the world would be a miracle if scientific theories were not at least approximately true. Another argument is the pessimistic meta-induction, which questions it by pointing out how many past theories were eventually abandoned. Alternative forms of realism, including entity realism, structural realism, and partial realism, are examined to offer more nuanced perspectives. The discussion also addresses the problem of underdetermination, where multiple theories can explain the same evidence, raising questions about how we determine scientific truth. These ideas lead to deeper philosophical concerns about truth, observation, knowledge, and the limits of human explanation. The debate illustrates how science and philosophy collaborate to deepen our understanding of the world, cultivating a thoughtful and critical perspective on scientific knowledge.



## Self-Assessment

1. Why is philosophical reflection significant in explaining scientific theories and practices?
2. What is the difference between scientific realism and scientific anti-realism?
3. What is the no-miracles argument, and how does it support scientific realism?
4. How do anti-realists use the pessimistic meta-induction to question scientific realism?
5. What are the main ideas of entity realism, structural realism, and partial realism?
6. What is meant by metaphysical, semantic, and epistemic commitments in the context of scientific realism?

7. In what ways does the problem of underdetermination affect the debate between realists and anti-realists?

## Assignments

1. Explain the relationship between philosophy and science by examining how they are connected in their search for knowledge. Discuss how philosophical reflection is essential for explaining the goals and limits of science.

2. Compare and contrast scientific realism and scientific anti-realism. Discuss how each view explains the aim of science, especially in relation to observable and unobservable entities.

3. Describe the three significant commitments of scientific realism: metaphysical, semantic, and epistemic. Discuss the no-miracles argument and how it supports the realist position.

4. Analyse the different forms of realism, such as entity realism, structural realism, and partial realism. Discuss how these forms of realism respond to the criticisms of traditional scientific realism.

## Reference


1. Kuhn, T. S. (1962). *The Structure of Scientific Revolutions*. University of Chicago Press.

2. Okasha, S. (2002). *Philosophy of science: A very short introduction*. Oxford University Press.

3. Chakravartty, A., & van Fraassen, B. C. (2018). What is scientific realism? Spontaneous Generations: *A Journal for the History and Philosophy of Science*, 9(1), 12–25.

4. Chalmers, A. F. (1999). *What is this thing called science? An assessment of the nature and status of science and its methods* (3rd ed.). Hackett Publishing Company.

5. Van Fraassen, B. C. (1980). *The scientific image*. Oxford University Press.

6. Putnam, H. (1975). Philosophy and our mental life. In H. Putnam, *Mind, language and reality* (Vol. 2, pp. 291–303). Cambridge University Press.

7. Psillos, S. (1999). *Scientific realism: How science tracks truth*. Routledge.

## Suggested Reading


1. Stanford, P. K. (2006). *Exceeding our grasp: Science, history, and the problem of unconceived alternatives*. Oxford University Press.
2. Devitt, M. (1991). *Realism and truth* (2nd ed.). Princeton University Press.
3. Fine, A. (1986). *The Shaky Game: Einstein, Realism, and Quantum Theory*. University of Chicago Press.


## Space for Learner Engagement for Objective Questions

Learners are encouraged to develop objective questions based on the content in the paragraph as a sign of their comprehension of the content. The Learners may reflect on the recap bullets and relate their understanding with the narrative in order to frame objective questions from the given text. The University expects that 1 - 2 questions are developed for each paragraph. The space given below can be used for listing the questions.

# UNIT 3
# Hempel's Deductive-Nomological Model of Scientific Explanation

## Learning Outcomes

Upon the completion of this unit, the learner will be able to:

- explain the concept and significance of scientific explanation
- gain a precise knowledge of Hempel's Deductive-Nomological (D-N) Model
- evaluate the logical structure and validity of scientific explanations using the D-N model
- critically examine the relationship between explanation and prediction, and assess major philosophical objections
- analyse the key criticisms and limitations of the D-N model

## Background

Scientific progress depends not only on observing and collecting data but also on explaining why events occur the way they do. At the heart of every scientific investigation lies a deeper philosophical question: 'What makes an explanation truly scientific?' One of the most influential efforts to answer this question comes from Carl Gustav Hempel, whose Deductive-Nomological (D-N) Model offers a logical and structured way to explain scientific explanations. Hempel's model gained particular influence in the physical and biological sciences, opening the door to more philosophical questions about the nature of causality, prediction, and scientific reasoning. Although later philosophers have criticised the model and proposed alternatives, Hempel's framework remains a foundational milestone in the field. It sparked lasting debates about how explanations should be judged, whether by logical form, empirical testability, or causal relevance. Understanding the D-N model provides a strong foundation for comprehending how science not only describes the world but also seeks to explain it in a logically sound and meaningful manner. Engaging with Hempel's work encourages philosophical reflection on what it means to explain something in science and why such explanations are essential to scientific discovery and progress.

## Keywords

Deductive-Nomological Model, Covering Law Model, Explanans, Explanandum, Inductive-Statistical Model (I-S Model), Causal Relationship

## Discussion

### 1.3.1 Explanations in Science

Explanations in science are a crucial way of clarifying the natural world. Scientists not only observe and describe things but also attempt to explain why things happen the way they do. A scientific explanation helps us elucidate the causes, laws, or principles behind a phenomenon. Scientists provide reasons for the things they study. These explanations differ from everyday explanations in that they follow systematic rules, utilise evidence, and are often supported by scientific laws and theories. In the philosophy of science, scholars attempt to clarify and refine the concept of explanation. They ask, 'What makes an explanation scientific?' 'What conditions must be met for something to count as a proper explanation in science?' To answer these questions, philosophers often try to create a definition that provides clear conditions. These are known as necessary and sufficient conditions, meaning that if those conditions are met, then the explanation is valid. A scientific explanation usually involves the following:

- Scientists attempt to explain why things happen the way they do

Explanans: The part that explains; the laws, principles, and facts.

Explanandum: The part that is explained; the event, fact, or phenomenon.

Let us take the example of a ball falling to the ground when dropped. To the question, 'Why did the ball fall?' the event we are trying to explain, that 'the ball fell', is called the explanandum. To answer this question, we examine the scientific reasons behind it, which are referred to as the explanans. In this case, the explanation involves the law of gravity, which states that any object near the Earth's surface is pulled toward the centre of the Earth by a gravitational force. The ball fell to the ground because of the gravitational force and the fact that it was no longer being held. This explanation employs a general scientific law (gravity) along with specific facts (the ball was released) to logically demonstrate why the event occurred. It is a good example of how scientific explanations work by combining

- Scientific explanation uses a general scientific law along with specific facts laws and conditions to explain real-world phenomena. There are different kinds of explanations in science:

Explanations of particular events – This explains why a specific plant grew faster under sunlight.

Explanations of general laws or patterns – This explains why objects fall to the ground using Newton's laws

Some explanations are very precise and complete. These are based on well-established laws and reliable data. Other explanations are more like 'sketches' or partial explanations, where we may not yet have all the facts or laws clearly stated. However, these still help to move closer to an explanation. In practical science, explanations are used not only to explain phenomena but also to predict future events. If we explain why something happens, we can often say what will happen in similar situations in the future. For example, explaining how diseases spread enables scientists to predict outbreaks and develop effective treatments. A significant point is that scientific explanations can evolve and change over time. As new evidence emerges or better theories are developed, existing explanations may be refined or replaced. This makes science a dynamic and evolving process. Explanations in science are a means of explaining the world through the use of evidence, logic, and general principles. They connect facts to causes and patterns. Scientific explanations play a key role in how science builds knowledge.

- Scientific explanations can evolve and change over time

## 1.3.2 Hempel's Deductive-Nomological Model of Scientific Explanation

Hempel's Deductive-Nomological Model of Scientific Explanation, also known as the Covering Law Model, is one of the most influential attempts in the philosophy of science to formally define what counts as a scientific explanation. It was proposed by German philosophers Carl Gustav Hempel and Paul Oppenheim in 1948. This model was developed to clarify the logical structure of scientific explanations, especially in the physical sciences. The central idea behind the model is that scientific explanations function like logical arguments, where the explanandum is deduced from a set of explanans. These premises must include at least one general law of nature and relevant specific conditions or facts. In this sense, an explanation is considered successful when it shows that, given the law and the conditions, the phenomenon must logically occur. Hempel outlined four essential conditions for an explanation to

- Hempel's Deductive-Nomological Model is also known as the Covering Law Model qualify as scientific under the Deductive-Nomological model:

1. The explanation must be a logically valid deductive argument, meaning the conclusion (the explanandum) must necessarily follow from the premises (explanans).

2. The explanans must contain at least one general law of nature, a universal statement that applies across time and space.

3. The statements in the explanans must be empirically testable; they should be subject to verification or falsification through observation or experiment.

4. The explanans should consist of true statements, since the validity of the argument alone does not guarantee that it reflects actual events unless its premises are true.

- The explanation must be a valid deductive argument, and the explanans must contain at least one general law

The first condition emphasises that the explanation must be a valid deductive argument. This means the explanans (the statements used to explain) must logically lead to the explanandum (the event to be explained). Hempel maintained that a proper explanation should include both general laws and specific facts. For example, general laws include statements like 'All metals conduct electricity' or 'All atoms have a nucleus at their centre'. Specific facts, on the other hand, are statements such as 'This metal conducts electricity' or 'This atom has a nucleus at its centre'. According to Hempel, at least one general law must always be part of the explanation. A phenomenon is explained by showing that it logically follows from a general law and relevant facts. To illustrate, suppose someone wants to explain why an iron nail rusted. The explanation could be that the nail was exposed to air and moisture for several days. According to the general law that iron reacts with oxygen and water to form rust, and given the fact that the nail was in contact with both, we can conclude that the nail rusted. This explanation follows Hempel's model because it includes one general law, a specific fact, and the phenomenon to be explained.

- The explanans must be empirically testable, and it must be true

The third condition, that the explanans must be empirically testable, ensures that only scientifically valid explanations are accepted. It helps to distinguish real science from pseudo-science. The fourth condition, that the explanans must be true, presents a philosophical challenge. In practice, scientific laws are not known with complete certainty; they are based on the best available evidence and are accepted as valid until disproved. Thus, while we may treat a law as accurate, it may later be revised or rejected. This uncertainty challenges the model's requirement for truth and shows that scientific explanations are not always as exact as the model assumes. Hempel's model is called the Covering Law Model because it explains an event by demonstrating that it logically follows from a general law of nature, along with specific facts. In this model, the phenomenon (the explanandum) is said to be 'covered' or explained by a general law (part of the explanans). The model shows that the event is understood by being included under a general scientific law.

- The general law and specific fact together form the explanans

For instance, to explain why a metal rod expands when heated, Hempel's model would use a general law such as 'All metals expand when heated' and a particular fact such as 'The rod is made of metal and was heated.' From these, we can logically conclude that 'The rod expanded.' Thus, the expansion is explained by deducing it from the general law and the specific condition. Here, the general law that all metals expand when heated covers the conclusion that the rod expanded, as the particular fact fits under the rule described by the law. In this explanation, the general law and specific fact together form the explanans, and the expansion of the rod is the explanandum. This illustrates how Hempel's model treats scientific explanation as a form of logical reasoning.

Example in argument form:

All metals expand when heated. (General law)

This rod is made of metal, and it was heated. (Particular fact)

∴ The rod expanded (Explanandum)

- The D-N model states that the explanation and prediction are logically symmetrical

One crucial feature of Hempel's model is its view that explanation and prediction are logically symmetrical. Both explanation and prediction employ the same reasoning process, combining general laws of nature with specific facts or initial conditions to draw a conclusion. Here, the same logical structure helps to make explanations and predictions. The only difference between them is whether the reasoning is applied before the event occurs (prediction) or after it has occurred (explanation). If we are aware of the relevant laws and conditions in advance, we can predict the outcome; if the event has already occurred, the same information can be used to explain it. In Hempel's view, every reliable prediction based on scientific laws and facts can also serve as a valid explanation after the fact. For instance, conservationists might observe widespread deforestation, low birth rates, and habitat destruction of the lion-tailed macaque. Using such ecological principles, they may predict that the lion-tailed macaque is at risk of extinction. If extinction does occur, the same factors used in the prediction can explain why it happened. Thus, explanation and prediction share an identical logical structure.

## 1.3.3 Criticism of the Deductive-Nomological Model

- The D-N Model has also faced several significant criticisms

Although Hempel's Deductive-Nomological Model is one of the most influential models of scientific explanation, it has also faced several significant criticisms. These criticisms demonstrate that, while the model is logically clear and well-structured, it does not always capture the complexity of how scientific explanations operate in practice.

### 1.3.3.1 The Model is Too Strict

- The D-N model is too strict to accommodate probabilistic explanations

One major criticism of the model is that it is too strict. There are many genuine scientific explanations, particularly in fields such as biology, psychology, and the social sciences, that do not fit neatly into the D-N model's structure. These disciplines often rely on statistical or probabilistic reasoning rather than strict, law-based deductions. For example, we may explain the spread of a disease using probabilities rather than fixed laws. This is not a strict deduction from any universal law; instead, it is based on probability rather than certainty. The D-N model cannot account for such explanations because it demands logical certainty and universal laws. Thus, it seems too narrow and excludes many real, meaningful scientific explanations simply because they do not follow a strict logical pattern. In response to this limitation, Hempel himself later proposed an alternative known as the Inductive-Statistical (I-S) Model, which allows for explanations based on probabilities rather than deduction. It better fits the way science works in fields where outcomes are not always predictable with certainty but can still be explained using reliable patterns or statistical evidence.

### 1.3.3.2 The Model is Too Liberal

Another criticism of the Covering Law Model is that it is too liberal, meaning it sometimes accepts explanations that appear correct in structure but lack genuine scientific meaning. A simple example involves imagining that every day at 6:00 AM, someone's alarm clock rings, and shortly afterward, the sun ris-

- The D-N model is too liberal because it can accept explanations that appear correct in structure but lack genuine scientific meaning

es. Now, someone might try to explain the sunrise by saying, "The sun rose because the alarm clock rang." This explanation aligns with the structure of the D-N model, which employs a general rule (Whenever the alarm rings at 6:00 AM, the sun rises) and a specific event (The alarm rang at 6:00 AM) to infer the outcome (The sun rose). However, we know that this is not a genuine scientific explanation. The ringing of an alarm clock has nothing to do with the sun rising.

- Sometimes, the D-N model allows non-causal explanations

In reality, both events occur around the same time due to a natural daily cycle; the Earth's rotation causes the sun to rise, completely independent of any alarm clock. This example shows how the D-N model can accept explanations that are logically valid in form but causally incorrect. Just because two events occur simultaneously or regularly together does not mean one causes the other. This highlights a significant flaw in the model, as it does not require a real cause-and-effect relationship. That is why it is called too liberal; it sometimes treats mere coincidences or unrelated patterns as if they were valid scientific explanations simply because they follow the logical structure of the D-N model.

### 1.3.3.3 The Model Assumes Laws Are Always True

- The D-N model assumes that the general laws used in explanations are always true

Another criticism is related to the truth of scientific laws. The D-N model assumes that the general laws used in explanations are always true. However, in real science, laws are often hypotheses based on the best available evidence, and they can be revised or even rejected later. This creates a philosophical problem; if the laws we use might turn out to be false, how reliable is an explanation that depends on them? Science often deals with provisional truths, and the D-N model does not account for this uncertainty.

### 1.3.3.4 The Model Confuses Explanation with Prediction

- According to the D-N model, both the explanation and prediction follow the same logical structure

According to Hempel's D-N model, both the explanation and prediction follow the same logical structure. He believed that if we can use general laws and facts to predict an event before it happens, we can use the same information to explain it after it occurs. However, many philosophers have pointed out that this is not always the case. They use the flagpole and shadow example to illustrate it. Imagine a flagpole standing in sunlight and casting a shadow on the ground. If we know the length of the shadow and the angle of the sun, we can calculate the height of the flagpole. This is a correct mathematical deduction. According to Hempel's model, since we can deduce the height of the flagpole from the shadow, the length of the shadow is also counted as an explanation of the height of the flagpole.

- Prediction and explanation are not always in the same logical structure

But that does not seem right. The shadow does not make the flagpole appear taller. It is the opposite: the height of the flagpole, along with the sun's position, causes the shadow to be a certain length. So, while we can use the shadow to predict the height, we would not say the shadow explains the height of the flagpole. The explanation must go from cause to effect, not the other way around. In general, if 'X' explains 'Y' based on specific laws and facts, it is not true that 'Y' also explains 'X' using the same laws and facts. This shows that prediction and explanation are not always in the same logical structure. Prediction often works from cause to effect, but explanation requires reflecting the proper causal direction. The flagpole example helps illustrate that scientific explanation is not just about logical deduction. It must also capture the real cause-and-effect relationship. Hempel's model does not fully account for this because it treats prediction and explanation as logically identical, even when they are not.

## Summarized Overview

A scientific explanation plays a crucial role in explaining how and why things occur in the natural world. Carl Gustav Hempel's Deductive-Nomological (D-N) Model is one of the most influential attempts to describe the logical structure behind such explanations. According to this model, a scientific explanation is similar to a logical argument, where the event to be explained is shown to follow necessarily from a set of general laws and specific facts. This approach is particularly useful in disciplines such as physics and biology, where explanations often rely on universal laws. The model highlights the importance of including at least one general law of nature, along with accurate and testable premises, in any explanation. It treats explanation and prediction as logically similar. That means, if a person can use laws and facts to predict something before it happens, the same information can be used to explain it afterwards. However, many philosophers have questioned this idea by pointing out that explanation must reflect the actual direction of cause and effect. A well-known example involves a flagpole and its shadow. While the shadow can be used to calculate the height of the flagpole, it does not explain it. Instead, the flagpole's height and the sun's position cause the shadow. This demonstrates that logical deduction alone is insufficient; an accurate explanation must also involve causality.

Several criticisms have been raised against Hempel's model. Some argue that it is too strict because it fails to include explanations based on probability, which are common in fields like biology and the social sciences. Others say that it is too broad because it allows explanations that follow logically but lack genuine scientific significance. For example, two events may occur together regularly but not be causally connected, yet the model might still treat one as explaining the other. There is also the issue that scientific laws are not always absolutely true; they are often revised or updated as discoveries are made. Despite these limitations, Hempel's model has helped to shape the way people think about scientific explanation. It brings clarity, structure, and logical discipline to the process of explaining phenomena and has laid the foundation for more flexible and modern approaches to explaining science.

## Self-Assessment

1. Explain the basic structure of Hempel's Deductive-Nomological (D-N) Model of scientific explanation.
2. What are the key conditions for a scientific explanation according to the D-N Model? Discuss the relevance of general laws and specific conditions in the D-N Model.
3. How does Hempel relate explanation and prediction in his model? Criticise the symmetry of explanation and prediction with an example.
4. Define the terms 'explanans' and 'explanandum' and explain their significance in scientific reasoning.
5. Examine the major criticisms raised against the D-N Model.

## Assignments

1. Explain the main features of Hempel's Deductive-Nomological (D-N) Model of scientific explanation. Discuss its logical structure, including the roles of general laws, specific conditions, explanans, and explanandum. Apply the D-N model to explain a scientific phenomenon of your choice, identify the relevant laws and facts, and show how the conclusion is logically derived from them.
2. Explain how Hempel's Deductive-Nomological (D-N) Model relates scientific explanation to prediction. Then, using the flagpole and shadow example, illustrate how this case challenges the model's assumption of logical symmetry between explanation and prediction.

3. Critically evaluate the main criticisms directed at Hempel's Deductive-Nomological (D-N) Model of scientific explanation. Discuss how the model has been viewed as both too strict and too liberal in its approach, and explain how these criticisms have led to further developments in the philosophy of science, including alternative models of explanation.

## Reference


1. Kuhn, T. S. (1962). *The Structure of Scientific Revolutions*. University of Chicago Press.
2. Okasha, S. (2002). *Philosophy of Science: A Very Short Introduction*. Oxford University Press.
3. Chalmers, A. F. (1999). *What Is This Thing Called Science? An Assessment of the Nature and Status of Science and Its Methods* (3rd ed.). Hackett Publishing Company.
4. Van Fraassen, B. C. (1980). *The Scientific Image*. Oxford University Press.
5. Putnam, H. (1975). Philosophy and Our Mental Life. In H. Putnam, *Mind, Language and Reality* (Vol. 2, pp. 291–303). Cambridge University Press.


## Suggested Reading


1. Stanford, P. K. (2006). *Exceeding Our Grasp: Science, History, and the Problem of Unconceived Alternatives*. Oxford University Press.
2. Hempel, C. G., & Oppenheim, P. (1948). *Studies in the Logic of Explanation. Philosophy of Science*, 15(2), 135–175. https://doi.org/10.1086/286983
3. Hempel, C. G. (1965). *Aspects of Scientific Explanation and Other Essays in the Philosophy of Science*. New York: Free Press.
4. Salmon, W. C. (1989). *Four Decades of Scientific Explanation*. Minneapolis: University of Minnesota Press.

## Space for Learner Engagement for Objective Questions

Learners are encouraged to develop objective questions based on the content in the paragraph as a sign of their comprehension of the content. The Learners may reflect on the recap bullets and relate their understanding with the narrative in order to frame objective questions from the given text. The University expects that 1 - 2 questions are developed for each paragraph. The space given below can be used for listing the questions.

# BLOCK 2
# Methodology of Science

# UNIT 1
# Inductivism

## Learning Outcomes

Upon the completion of this unit, the learner will be able to:

- describe what is meant by the scientific method and why it is important in science
- explain Francis Bacon's method of scientific induction
- identify the problem of induction, including the challenge of the inductive leap
- explain the key postulates underlying induction, such as the law of uniformity of nature and the law of universal causation
- evaluate the implications of Goodman's New Riddle for scientific reasoning and the formation of generalisations
- reflect critically on the influence of language, background knowledge, and community practices in shaping scientific inference

## Background

We live in a world that constantly challenges us to make sense of what we see, hear, and experience. From the movement of the stars to the behaviour of human beings, we seek patterns and explanations. Science has become one of the most potent and trusted tools in this search for understanding. It helps us explain natural phenomena, predict future events, and develop technologies that shape our lives. However, this also leads to deeper philosophical questions:

Can science always be trusted?

How do scientists arrive at the truths they claim to know?

What makes scientific knowledge more reliable than personal opinions or random guesses?

To address such questions, it is essential to examine the method of science itself. What steps do scientists follow when they study the world? How do they move from particular observations to general laws or theories? And what assumptions guide this journey from experience to knowledge? This unit discusses these issues with a focus on the inductive method in science while also reflecting on its strengths and inherent limitations.

## Keywords

Induction, Baconian Method, Four Idols, Law of Uniformity of Nature, Law of Universal Causation, Inductive Leap, New Riddle of Induction

## Discussion

### 2.1.1 Methods in Science

- The scientific method has evolved from Aristotle's observational and logical approach to the emergence of new models in the 17th century

The method of science is one of the most important and widely discussed topics in the philosophy of science. Philosophers have long debated how science arrives at knowledge that is considered reliable and objective. This question is so fundamental that some even say that explaining the method of science is key to explaining science itself. In ancient times, Aristotle provided a detailed framework for acquiring scientific knowledge. His approach was based on observation, logic, and classification, and his ideas remained influential for many centuries, especially until the 16th century. However, by the 17th century, a new spirit of inquiry began to shape the scientific world. Thinkers began to question traditional methods and sought new approaches to explaining nature. This gave rise to two major models of the scientific method:

1. Inductivism
2. Hypothetico-deductive method

These models represent two distinct perspectives on the generation of scientific knowledge.

- According to inductivism, science should begin with the careful observation of nature

The first major view is called inductivism, which is most closely associated with the English philosopher Francis Bacon. According to inductivism, science should begin with the careful observation of nature. Scientists are expected to collect many instances of a phenomenon and, from these particular observations, derive general laws or theories. For example, after repeatedly observing that whales give birth to live young and nurse them with milk, we can conclude that whales are mammals. This process of moving from particular observations to arrive at general conclusions is known as induction. Inductivism emphasises the role of the senses in gaining knowledge and is rooted in the philosophical tradition of empiricism. Empiricists believe that all knowledge ultimately comes from sensory experience. Bacon believed that by systematically collecting data, eliminating bias, and drawing careful generalisations, science could uncover the laws of nature. Bacon warned about the various mental biases, prejudices, or 'idols' that can mislead the human mind.

- The hypothetico-deductive method suggests that science begins with the formulation of a hypothesis

On the other hand, the hypothetico-deductive method presents a distinct account of how science operates. This model is associated with the rationalist tradition and is linked to the French philosopher René Descartes. In this approach, science begins not with observation but with the formulation of a hypothesis. A hypothesis is an educated guess or a proposed explanation for a phenomenon. From this hypothesis, the scientist deduces specific consequences or predictions. These predictions are then tested through observation and experiment. If the predictions hold true, the hypothesis is supported, at least tentatively; if the predictions fail, the hypothesis must be revised or rejected. This method places more emphasis on reason than on sensory experience. Rationalists argue that certain aspects of our knowledge are independent of sensory input and can be derived through logical reasoning. The hypothetico-deductive method reflects this view, as it enables scientists to propose theories based on intuition, creativity, or mathematical reasoning, and then use experiments to test and validate them.

- In practice, modern science combines both inductivist and hypothetico-deductive approaches

The two methods offer different yet complementary perspectives on scientific inquiry. Inductivism emphasises the gradual and careful accumulation of knowledge from observed facts, whereas the hypothetico-deductive method emphasises the role of creative thinking and rigorous testing. In practice, modern science often combines both approaches. Observations help form hypotheses, and hypotheses guide further observations. Together, these methods have shaped the way science is practised and understood in the modern world.

## 2.1.2 The Baconian Model

Inductivism is the view that the method of science is induction. This means that science begins with specific observations and gradually builds up to general conclusions. This model of scientific reasoning was strongly promoted by Francis Bacon, who believed that the proper path to knowledge begins with direct observation of the world around us. According to

- According to the Baconian model, the scientist begins without any preconceived theory or prejudices

the Baconian model, the scientist must begin without any preconceived theory or prejudices. Instead, they should observe natural phenomena, gather facts, and record as much detail as possible. For instance, by observing various metals, one can see that iron, copper, silver, and gold all expand when heated, leading to the general conclusion that 'All metals expand when heated'. This kind of reasoning, where one moves from specific observations to a broader generalisation, is called induction. Bacon argued that induction provides a reliable path to true knowledge. He believed that if enough observations are collected under varied conditions, then general patterns or regularities can be discovered. These patterns, once repeatedly confirmed, may be considered scientific laws. These laws, when accumulated over time, represent a body of reliable knowledge about reality. The greater the number of confirmed observations, the stronger the foundation of science.

## 2.1.3 Baconian Induction

- For Bacon, science aimed to discover the true causes of natural phenomena through systematic observation and generalisation

Francis Bacon is one of the key figures who laid the foundation for modern science. He is known for proposing a new method of scientific thinking in the 17th century, which is commonly referred to as Baconian induction. Bacon's ideas were a response to the overdependence on ancient authorities and purely logical reasoning that dominated medieval scholarship. He wanted science to begin not with assumptions or inherited theories, but with real-world observations. His method is fully developed in his major work, Novum Organum, where he offers both a critique of old habits of thought and a positive proposal for how science should proceed. Bacon believed that science aimed to discover the true causes of natural phenomena, and that this could be achieved through systematic observation and generalisation. He argued that knowledge should not be built solely on speculation or abstract reasoning, but must arise from the careful study of nature. This approach came to be known as inductivism because it proceeds from particular observations to general truths. In other words, scientists collect numerous individual observations, identify patterns, and then gradually build upon them to form broader conclusions or scientific laws.

However, Bacon was aware that human thinking is often clouded by biases, errors, and preconceived ideas. To address this, he introduced what he called the 'Four Idols', which are false notions or mental prejudices that distort our understanding. The four idols are:

1. Idols of the Tribe
2. Idols of the Cave
3. Idols of the Marketplace
4. Idols of the Theatre

The Idols of the Tribe refer to the common human tendency to view the world through human-centred lenses rather than as it truly is. The Idols of the Cave refer to the individual biases shaped by personal experience or education. The Idols of the Marketplace arise from the misuse or ambiguity of language that can confuse thinking. Finally, the Idols of the Theatre are false beliefs that come from blindly following traditional philosophies or systems of thought. Bacon argued that, to practise true science, we must first become aware of and overcome these idols or presuppositions. While Bacon promoted the idea of 'presuppositionless' observation, he did not envision science as a random or passive activity. He compared the scientist to a bee, gathering nectar from flowers and transforming it into something new.

- For Bacon, to practise true science, we must first overcome the idols

According to Bacon, a scientist should begin by preparing a complete and detailed record of all natural and experimental facts related to the object or phenomenon under investigation. This collection of data must be carefully organised and structured. Once the information is gathered, the scientist analyses it by arranging it into tables or lists. Through methodical comparison, the scientist can begin to identify and explain the actual conditions that give rise to the phenomenon. Bacon believed that such a systematic approach would lead to the development of scientific theories that are more reliable than those based on mere guesswork or abstract reasoning. Bacon outlined a threefold method for scientific investigation: a table of presence (listing all known cases where the phenomenon occurs), a table of absence (listing similar cases where it does not occur), and a table of degrees (observing cases where the phenomenon appears in varying intensities).

- Bacon's method uses empirical data and comparison to uncover causes and build reliable theories

For instance, to explain what causes heat, a scientist would begin by observing various situations where heat is clearly present, such as sunlight, fire, boiling water, or warm animal bodies. These are known as positive instances. Next, the scientist would look at similar situations where heat is not present, such as moonlight or starlight. These are called negative instances.

- Bacon's method emphasises comparing positive, negative, and varying instances to identify the true causes of phenomena accurately

Finally, the scientist would examine cases where heat is present in varying degrees to notice when and how the intensity of heat changes. By carefully comparing these examples, the scientist can determine which features are consistently present when heat is present and absent when it is absent. One important part of Bacon's method is its emphasis on negative instances, cases where a phenomenon does not occur. By identifying when and where something does not happen, the scientist avoids making quick or careless generalisations based only on positive cases. This helps refine theories and get closer to the actual cause of things.

- Bacon's philosophy of science emphasised mental purification through disciplined and unbiased inquiry

Bacon's philosophy of science was attractive because it called for a kind of mental purification. He wanted scientists to remove personal biases, traditional beliefs, and false assumptions from their minds before beginning any investigation. His ideas emerged at a time when there was growing excitement about the power of science, and people were beginning to move away from superstition and outdated thinking. Bacon's model of induction was optimistic about the future of science. He believed that if humans followed this method, then science could steadily progress and uncover the true causes of natural events. His approach inspired a generation of scientists and helped shape the modern scientific method.

- Criticism against induction is that no observation is ever completely free from theory

Despite its influence, Baconian induction has also been criticised. Later philosophers, such as Karl Popper and Thomas Kuhn, pointed out that no observation is ever completely free from theory. We often observe things with some idea already in our minds. Moreover, collecting unlimited observations without any guiding hypothesis is practically impossible. Still, Bacon's model remains a landmark in the history of science for promoting observation, caution, and the rejection of blind tradition. He believed that by following his method, science could steadily progress and uncover the true causes of natural events. In contrast, later philosophers have pointed out that no method can guarantee truth.

## 2.1.4 The Paradox of Induction

Induction is a method of reasoning where a universal conclusion is drawn from particular observations. For instance, after a few experiments in which hydrogen and oxygen combine to form water, we may generalise that $H_2$ and $O_2$ always produce water. In such cases, we are making a general claim based on limited instances. This is the process of induction. It is one of the most common and valuable ways to form knowledge, especially in science. However, induction also presents a deep philosophical issue, known as the problem of induction. The problem of induction arises from a fundamental question: How can we derive a general conclusion based on a few particular observations? For instance, we observe many crows, and since their colour is black, we conclude that all crows are black. However, the problem lies in the fact that we have not seen every crow that exists or will exist. What if a white crow appears tomorrow? This shows that any general statement based on limited observations can constantly be challenged by new, unobserved cases. This jump from some to all is known as the inductive leap. This leap from the known (observed cases) to the unknown (unobserved cases) is what makes induction uncertain and risky.

- The problem of induction asks how general conclusions can be drawn from limited observations

Philosophers, especially David Hume, have questioned the logical basis of induction. Hume argued that there is no rational justification for believing that the future will always resemble the past. Just because something has always happened in a certain way does not guarantee it will continue to happen in the same way in the future. For instance, just because the sun has risen every day in the past does not mean it must rise tomorrow. This means that inductive generalisations are always open to doubt and possible revision. This is the core of the problem of induction. In everyday life and scientific practice, induction is widely used. Scientists perform experiments on a small number of cases and use those results to formulate general laws. Without induction, we cannot predict, generalise, or form scientific theories. So, although induction is philosophically problematic, it is practically unavoidable. Though we depend on induction for knowledge, we cannot fully justify its truth.

- Hume says there is no rational justification for believing that the future will always resemble the past

To address this issue, philosophers have introduced the idea of postulates of induction. A postulate is a fundamental principle that is not proven but assumed to be true because it is necessary. These postulates act as the foundational beliefs that make induction possible. There are two key postulates:

1. Law of Universal Causation: This postulate holds that every event in the universe has a cause. Nothing happens without a cause. Every effect is produced by a specific set of causes. This belief allows scientists to search for causes behind observed effects and form cause-effect explanations of natural phenomena. For example, the cause of rusting in iron is due to the chemical reaction between iron, oxygen, and moisture

(water) in the air. This process, called oxidation, leads to the formation of iron oxide (rust). If we deny the causal link between moisture exposure and rust formation, we cannot explain or predict why iron objects left in humid environments deteriorate more rapidly, thereby undermining the entire scientific explanation of rust. Therefore, without acknowledging causation, scientific explanations lose their explanatory and predictive power.

- Law of Universal Causation holds that every event in the universe has a cause

2. Principle of Uniformity of Nature: This postulate is the belief that nature behaves consistently and regularly. The exact causes under the same conditions will produce the same effects. This means the laws of nature do not change randomly. Smoke follows fire today and will continue to do so under similar conditions tomorrow. This assumption helps scientists make predictions and apply scientific laws to future cases. Without uniformity, no generalisation could ever be reliable.

- Principle of Uniformity of Nature holds that nature behaves consistently and regularly

Both postulates reflect a broader idea: that the universe is an orderly system governed by laws and patterns. These beliefs are not proven logically but are accepted as necessary for scientific reasoning. If we did not accept them, we would have no way to make predictions or systematically explain the world. So, while the problem of induction shows that we cannot be logically certain about generalisations, these postulates allow us to proceed with a working model of science. Modern philosophers have explored different responses to the problem of induction. Karl Popper argued that science should not attempt to prove general statements through induction but instead focus on falsification, testing theories by attempting to disprove them. Others accept that while induction is not logically valid, it is justified because it works reliably in practice. Still, the problem of induction remains a central issue in the philosophy of science.

- The postulates of induction allow us to proceed with a working model of science

## 2.1.5 Goodman's New Riddle of Induction

Nelson Goodman, a 20th-century American philosopher, presented a significant challenge to the traditional explanation of induction through what is called the 'New Riddle of Induction'. His approach extends beyond the classical problem of induction, compelling us to examine the logical structure and justification of inductive reasoning itself. The traditional problem of induction asks how we can justify our belief that

- Nelson Goodman questioned the logic of expecting the future to mirror the past, deepening the problem of induction

the future will resemble the past. For example, if we have seen hundreds of crows, and every single one has been black, we naturally expect that the next crow we see will also be black. This is how inductive reasoning works. We observe many examples and then make a general rule. But the philosophical problem is, on what logical basis do we believe that all future crows will also be black, just because all the past ones were? Goodman begins by pointing out that even the rules of deduction, which are considered certain, are justified in a circular but acceptable way. For example, consider the argument:

If it rains, the ground gets wet.

It is raining.

Therefore, the ground is wet.

- Goodman calls the circular reasoning between logical rules and accepted arguments a 'virtuous circle'

This follows a logical rule called modus ponens, which means, 'If A is true, and A implies B, then B is also true.' Now, how do we know modus ponens is correct? We usually say the rule is correct because it aligns with the kind of reasoning we already believe is sound. In other words, we accept the argument because it follows the rule, and we accept the rule because it gives us arguments like this that we already trust. So, there is a kind of circular reasoning here; the rules support the arguments, and the arguments support the rules. Nelson Goodman admits this is circular, but he says it is not a bad kind of circle. He calls it a 'virtuous circle' because the rules and practices work well together and help us reason correctly. This mutual support between rules and reasoning maintains the entire system's stability and functionality.

- Goodman argues induction depends on accepted practices but lacks clear rules

Goodman suggests that we should treat induction similarly. Predictions are justified if they conform to accepted canons of induction, and those canons are valid if they reflect established inductive practices. This means that, rather than seeking external or ultimate justification for induction, we recognise that inductive reasoning is justified within a system of mutual agreement between practice and principle. However, this still leaves us with an important question: What are the valid canons of induction? While deductive reasoning has well-known logical laws, no universally accepted or precisely stated rules for inductive reasoning exist. Developing such rules remains an open task in philosophy. To explain why this task is so complex, Goodman introduces his famous 'New Riddle.' Suppose we make the following inductive inference:

Emerald 1 is green.

Emerald 2 is green.

Emerald 1000 is green.

Conclusion: All emeralds are green.

- Goodman challenges standard inductive reasoning by introducing the unusual concept of 'grue'

This seems like a reasonable generalisation. It is based on repeated observation, and all the instances (green emeralds) confirm the general conclusion. It gives us good reason to believe that the next emerald we see will also be green. So far, this appears to be a good example of standard inductive reasoning. But philosopher Nelson Goodman introduces a clever twist. He asks us to think about a different, unusual word—'grue.' Goodman defines grue like this:

An object is grue if: It is green and has been observed before a specific date (say, the year 2025), or it is blue and has not been observed before that date.

This definition may sound strange, but it is logically consistent. Based on this definition, all emeralds we have observed before 2025 are not only green; they are also grue, because they are green and have been observed before the cut-off time. So, based on the same observations, we could also reason as follows:

Emerald 1 is grue.

Emerald 2 is grue.

Emerald 1000 is grue.

Conclusion: All emeralds are grue.

- Goodman's riddle shows that inductive reasoning depends not just on evidence but on using suitable, projectible predicates

This seems just as logically valid as the earlier argument, but the conclusion is quite different. If we believe that all emeralds are grue, then we should expect that emeralds observed after 2025 will be blue, which contradicts the first argument, where we expected them to be green. The first argument assumes that all emeralds, past and future, are green. The second argument expects emeralds after 2025 to be blue (because that is part of the definition of grue). Thus, we are faced with a paradox; the same evidence supports two contradictory conclusions. The logical question raised by Goodman is, why do we prefer the predicate green over grue? Why do we consider one generalisation valid and the other absurd? The riddle shows that the structure of inductive reasoning cannot by itself determine the reliability of the inference. We must also ask whether the predicates or terms used in the argument are suitable for projecting into the future. Goodman calls these 'projectible predicates.' A valid inductive inference depends on using projectible predicates, but how do we determine which ones are projectible?

One suggestion is that we should avoid terms that include a reference to a particular time or place, as grue does. It might seem unnatural to define a term based on whether an object was observed before or after a specific year. This kind of time-dependent definition makes grue seem artificial because it links the property of an object (like colour) to when it is observed, which feels less natural and harder to trust for future predictions. However, Goodman points out that many standard scientific terms also rely on definitions that involve time and other terms. For instance, he proposes another strange predicate called bleen, defined as: an object is bleen if it is blue before a particular time and green afterwards. The problem remains: what makes green more natural or projectible than grue or bleen? Some philosophers have attempted to explain this by arguing that green is a more 'primitive' or simple concept, meaning it is basic and not defined in terms of other complex concepts, whereas grue is described using more complex or compound terms. But Goodman argues that this depends on our existing language and background knowledge. In a different linguistic system, grue might be the simple term, and green the artificial one. So, even the idea of simplicity does not give us a final answer.

- The difference between projectible and artificial terms like green and grue depends on language and context, not objective simplicity

Goodman's New Riddle of Induction teaches us that not all generalisations can be trusted, even if they are based on many observed examples. The success of inductive reasoning depends not just on how many times we have seen something happen, but also on the concepts and words we use to describe what we see. When scientists do experiments, they do not just look at raw data. They use their background knowledge to decide what factors are essential and what can be ignored. This means that scientific reasoning is more than just collecting facts; it is also about how we explain and describe those facts. Goodman shows that we cannot build a reliable method of induction just by looking at observations. Instead, our reasoning is shaped by the language we speak, the experience we have, and the practices accepted by our scientific community.

- Goodman's riddle shows that inductive reasoning relies not just on observations but also on the language, concepts, and background knowledge

Induction is not only about how often something happens. It is also about whether we are using the right kind of concept to talk about it. The real issue in induction is choosing the right kind of description (what Goodman calls the 'predicate') to make future predictions. So, to improve our understanding of induction, we need to think not only about the examples

- The real issue in induction is choosing the right kind of description we collect but also about how we describe them, and which descriptions are reasonable and useful for making general conclusions.

## Summarized Overview

Induction is a method of reasoning that moves from specific observations to general conclusions. Francis Bacon emphasised this approach, encouraging systematic observation and the elimination of biases through his concept of the Four Idols. He proposed a structured process for scientific inquiry that involves comparing instances where a phenomenon is present, absent, and varies in intensity. Alongside inductivism, the hypothetico-deductive method offers an alternative approach, beginning with a hypothesis and testing it through observation and experimentation. While inductivism is rooted in sensory experience, the hypothetico-deductive method highlights the role of logic, creativity, and reasoning in science.

The problem of induction arises from the uncertainty of generalising beyond observed cases. Philosophers like David Hume questioned the logical basis of expecting the future to resemble the past. Inductive reasoning relies on assumptions such as the law of universal causation and the uniformity of nature, which are necessary but not provable. Nelson Goodman further challenged induction with his concept of the 'New Riddle,' showing that the concepts we use, such as 'green' or 'grue,' can affect the reliability of predictions. These reflections reveal that scientific knowledge depends not just on repeated observations but also on how observations are framed and interpreted within a shared system of explanation.



## Self-Assessment

1. What is inductive reasoning, and how does it differ from deductive reasoning in the context of scientific inquiry?
2. Explain Francis Bacon's contribution to the scientific method. What are the Four Idols he identified, and how do they affect human explanation?
3. How does the hypothetico-deductive method function, and in what way does it complement the inductive method in scientific practice?
4. Explain the 'inductive leap,' and why it is considered a philosophical problem in the justification of scientific knowledge.
5. Discuss the postulates of induction. Why are they necessary for scientific reasoning despite being unprovable?
6. What is Nelson Goodman's 'New Riddle of Induction,' and how does the concept of 'grue' challenge the reliability of inductive generalisations?

## Assignments

1. Discuss Francis Bacon's contribution to the development of the scientific method with special reference to his theory of induction and the Four Idols. How do his ideas aim to purify human explanation in scientific inquiry?
2. Examine the role of induction in scientific reasoning. In your answer, critically evaluate the philosophical challenges posed by the problem of induction and the assumptions it relies on, such as the uniformity of nature and universal causation.
3. Evaluate Nelson Goodman's 'New Riddle of Induction' and its implications for scientific knowledge. How does the concept of 'grue' question the reliability of inductive generalisations, and what does this suggest about the role of language and conceptual framing in science?

## Reference


1. Okasha, S. (2016). *Philosophy of science: A very short introduction* (2nd ed.). Oxford University Press.
2. Kuhn, T. S. (1996). *The structure of scientific revolutions* (3rd ed.). University of Chicago Press.
3. Ladyman, J. (2002). *Understanding philosophy of science*. Routledge.
4. Chalmers, A. F. (2013). *What is this thing called science?* (4th ed.). Open University Press.
5. Hume, D. (2000). *An enquiry concerning human understanding* (T. Beauchamp, Ed.). Oxford University Press. (Original work published 1748)




## Suggested Reading


1. Lakatos, I. (1970). Falsification and the Methodology of Scientific Research Programmes. In I. Lakatos & A. Musgrave (Eds.), *Criticism and the Growth of Knowledge* (pp. 91–196). Cambridge University Press.
2. Bacon, F. (2000). *The New Organon* (L. Jardine & M. Silverthorne, Trans.). Cambridge University Press. (Original work published 1620).
3. Godfrey-Smith, P. (2003). *Theory and reality: An introduction to the philosophy of science*. University of Chicago Press.
4. Goodman, N. (1983). *Fact, fiction, and forecast* (4th ed.). Harvard University Press.
5. Popper, K. R. (2002). *The logic of scientific discovery*. Routledge. (Original work published 1934).

## Space for Learner Engagement for Objective Questions

Learners are encouraged to develop objective questions based on the content in the paragraph as a sign of their comprehension of the content. The Learners may reflect on the recap bullets and relate their understanding with the narrative in order to frame objective questions from the given text. The University expects that 1 - 2 questions are developed for each paragraph. The space given below can be used for listing the questions.

# UNIT 2
# Methods of Science

## Learning Outcomes

Upon the completion of this unit, the learner will be able to:

- explain the scientific method and how it helps in gaining reliable knowledge
- describe and compare inductivism and hypothetico-deductivism as methods used in science
- explain the key ideas of positivism and its role in shaping modern science
- identify what verificationism means and why it was essential to logical positivists
- explain Karl Popper's idea of falsification and how it changed the way science is understood

## Background

Science has become a central part of human life, influencing the way we think, live, and make decisions in almost every field. However, for science to be trusted, it is essential to explain how scientific knowledge is formed, tested, and refined. How do scientists arrive at conclusions? What makes scientific knowledge reliable and different from other kinds of knowledge, like personal belief or tradition? To answer these questions, many philosophers and thinkers have developed various methods to explain the nature of science. Over time, ideas such as observation, experimentation, reasoning, hypothesis testing, and objectivity have shaped the foundation of scientific thinking. Understanding these methods helps to see not just how science finds answers but also how it remains open to change when new evidence appears.

## Keywords

Scientific method, Inductivism, Hypothetico-deductivism, Karl Popper, Positivism, Logical positivism, Vienna Circle, Verificationism, Falsificationism, Verisimilitude

Discussion

## 2.2.1 Methods of Science

The scientific method is a structured approach to inquiry that aims to generate reliable knowledge about the natural world. It involves a series of logical steps, beginning with observation, followed by the formulation of hypotheses or theories, and culminating in experimentation and testing to validate or refute these ideas. The scientific method emphasises objectivity, evidence, and repeatability, ensuring that conclusions are based on facts rather than beliefs or assumptions. It is built on the principle that knowledge must be derived from empirical data, making the process both systematic and verifiable. The goal of scientific inquiry is not merely to accumulate facts but to uncover general principles and laws that govern the phenomena we observe. This approach contrasts with other methods of explaining the world, such as those rooted in tradition or personal belief, by demanding rigorous evidence and logical reasoning.

- The scientific method emphasises objectivity, evidence, and repeatability

Over time, various schools of thought have shaped and influenced the development of the scientific method. Among the various philosophical methods proposed to explain how science works, two of the most influential are inductivism and hypothetico-deductivism. Although distinct in their orientation, both offer valuable insights into the nature of scientific reasoning. Inductivism holds that scientific knowledge is primarily derived from careful and repeated observation. Observations are recorded without any preconceived notions, and from a sufficiently large and varied set of observations, scientists derive general laws or theories. This model suggests that certainty is the hallmark of science and that the foundation of scientific knowledge lies in the observable and repeatable aspects of nature. The belief is that if no counterexample has been found and the observations are consistent, one can safely assume the truth of the generalisation.

- Inductivism holds that scientific knowledge is primarily derived from careful and repeated observation

However, inductivism faces a significant philosophical challenge known as the problem of induction. The problem arises from the logical gap between finite observations and universal conclusions. Just because something has happened consistently in the past does not guarantee it will continue in the future. Therefore, although inductivism provides a valuable account of how patterns in nature are identified, it is limited in its ability to justify scientific knowledge fully. In response to these limitations, the hypothetico-deductive model emerged

- The problem of induction is the logical gap between finite observations and universal conclusions as an alternative method of science. This approach, notably advanced by Karl Popper, suggests that science progresses not by seeking confirmation but through inferences and rigorous testing. According to this view, scientific inquiry begins with a hypothesis rather than relying solely on observation. The hypothetico-deductive method shifts the focus from certainty to critical testing, acknowledging that all scientific knowledge is provisional.

- Inductivism and hypothetico-deductivism offer models for how science progresses and justifies its claims

Both inductivism and hypothetico-deductivism attempt to explain how science advances and how scientific claims are justified, yet they do so from fundamentally different perspectives. In modern scientific practice, elements of both approaches are often combined. Observations may inspire hypotheses, which are then tested through deduction and experimentation. These diverse perspectives on scientific methods reflect different philosophies of knowledge and how we can best achieve a deeper understanding of the world around us. The methods of science are not static; they evolve as discoveries are made and new philosophical ideas emerge.

## 2.2.2 Positivism

Positivism is a philosophical approach that has had a significant influence on the development of modern science. It is based on the belief that genuine knowledge can be gained through direct experience, observation, and logical reasoning. In simple terms, if something cannot be seen, tested, measured, or proven logically, then it is not considered valid knowledge according to positivism. This approach suggests that science should only deal with things that can be observed and should avoid ideas that cannot be tested or verified. The roots of positivism go back to the 19th century, with the French philosopher Auguste Comte being one of its principal founders. Comte believed that human thinking develops through three main stages. The first was the theological stage, where people explained the world through religious beliefs and the actions of gods. The second was the metaphysical stage, where explanations were more abstract and based on unseen forces or principles. The third and final stage, which Comte referred to as the positive stage, was the scientific stage. At this stage, people employed observation, experimentation, and reasoning to explain the world in a systematic and objective manner. For Comte, this positive method of science was the most reliable and advanced way of gaining knowledge.

- Positivism holds that genuine knowledge comes from experience, observation, and logical reasoning

In the early 20th century, positivism was further developed into a form known as logical positivism, primarily by a group of philosophers collectively referred to as the Vienna Circle. These thinkers sought to refine the principles of science even further, making them more precise and rigorous. They argued that a statement is meaningful only if it can either be tested by observation or proven through logic and mathematics. This idea is also known as verificationism. According to verificationism, statements like '$H2 + O2 = H2O$' or '$1 + 1 = 2$' are meaningful because these statements can be verified. However, statements such as 'God exists', 'There is life after death', 'The soul is immortal', etc., were considered meaningless by logical positivists because such statements cannot be proven or tested by any scientific method. This strict approach aimed to separate scientific knowledge from religious, emotional, or speculative beliefs.

- Positivism was further developed into a form known as logical positivism

Positivism also emphasised that science should be objective, meaning it should be free from personal feelings, beliefs, or values. According to this view, scientists should focus exclusively on facts that can be observed and measured. Positivists believed that science should be as neutral and impersonal as possible, which helps to avoid assumptions or interpretations that go beyond the observable data. This approach contributed to the image of science as a method that guarantees certainty and avoids error by adhering closely to observable reality. However, over time, positivism faced intense criticism. Many philosophers have noted that science frequently deals with entities that cannot be directly observed, such as atoms, electrons, gravitational force, or genes; yet, these concepts remain meaningful and essential for scientific progress.

- Positivists believed that science should be as neutral and impersonal as possible

Moreover, critics argued that science not only describes what is seen, but also involves interpretation, imagination, and theoretical assumptions. Scientific theories often guide what we observe and how we interpret it, so observation is not as neutral or straightforward as positivists believed. Also, the strict idea that only verifiable statements are meaningful was challenged because it excluded too many valuable and essential types of knowledge. Despite these criticisms, positivism made a significant contribution to shaping the modern scientific worldview. It helped to promote careful observation, the use of logic, and a strong emphasis on evidence in scientific work. Even now, many scientists adopt a generally positivist attitude when they rely on experiments, seek objectivity, and focus on measurable outcomes. While positivism in its strict form is no

- Critics argue that observation is not as neutral or straightforward as positivists believed longer widely accepted in philosophy, its core ideas continue to influence how science is taught, practised, and understood.

## 2.2.3 Verificationism

- Verificationism states that a statement is meaningful only if it can be empirically verified

Verificationism is a key concept that emerged from the broader philosophy of positivism, particularly associated with the ideas of logical positivists such as the members of the Vienna Circle in the early 20th century. It was an attempt to clearly define what counts as meaningful knowledge, especially in the context of scientific language. The central claim of verificationism is that a statement is meaningful only if it can be empirically verified. That is, a statement can be confirmed or disproved through sensory observation and experience, or if it is a logical or mathematical truth. This idea had a significant influence on the understanding of science and scientific language during the early stages of modern philosophy of science.

- Verificationism aimed to make scientific language clear, objective, and free from speculation

The background of verificationism lies in the broader context of two distinct views on the method of science: inductivism and the hypothetico-deductive method. For the inductivist, science progresses in a bottom-up fashion, where facts are established first through observation and theories are developed later. This method, which came to be known as Baconian induction, formed the foundation of the positivist view of science. Building on inductivism, the logical positivists introduced the principle of verification as a criterion for meaning. They believed that scientific knowledge should be strictly based on observable facts, and any statement that could not be verified through observation was considered meaningless. For example, statements about metaphysical entities, religious beliefs, or ethical values were rejected by verificationists because they could not be proved by sense experience or logical analysis. Verificationism aimed to make scientific language clear, objective, and free from speculation. It thus tried to protect science from unverifiable and non-scientific claims.

According to A.J. Ayer, a leading figure of logical positivism, there are two types of verification: strong verification and weak verification. A statement is strongly verifiable if it can be conclusively shown to be true through direct observation or experience. It is weakly verifiable if there is at least some possible observation that could support it, even if not conclusively. Since strong verification is rarely feasible in complex sciences, most logical positivists, including Ayer and Rudolf Carnap, accepted weak verification as a more

- There are two types of verification: strong verification and weak verification

practical criterion for verification. Many important scientific ideas, particularly in fields such as physics, cannot be directly observed. Concepts such as atoms, electrons, or gravity cannot be seen or touched, but they are still essential for explaining and predicting real-world events. These kinds of theories are meaningful and valuable even though they cannot be directly verified through observation. Carnap made significant contributions to the idea that scientific language should be logically structured and grounded in empirical content. These refinements helped the verification principle become more flexible; however, it continued to face criticism.

- A significant criticism of verificationism is its assumption that observations are always neutral and unbiased

One of the biggest criticisms of verificationism was that it assumed observations were always neutral and free from any influence. However, many philosophers argued that all observations are shaped by the theories and beliefs of the observer. This means that we never really observe things in a completely unbiased way. What we notice and how we interpret everything is influenced by our existing thoughts and expectations. So, instead of theories following observation, they often precede it and guide the observation. This argument weakened one of the main ideas of verificationism, that scientific knowledge can be built purely on neutral, objective facts. Another major criticism was that verificationism made its rules for meaningfulness too strict. While the ideas of strong and weak verification helped improve the verification principle, the theory still had serious weaknesses. Its strict focus on what can be directly observed or logically proven left out much of what makes science powerful.

- Verificationism aimed to offer a precise standard for meaningfulness and truth in science

Verificationism encouraged rigorous standards for clarity and empirical support in scientific discourse, prompting philosophers to consider the boundaries of meaningful language carefully. It represents a significant milestone in the evolution of scientific thought. It aimed to offer a precise standard for meaningfulness and truth in science by focusing on what can be observed and logically demonstrated. Although later challenged and refined, especially by thinkers such as Karl Popper, the verificationist spirit is evident in the scientific emphasis on evidence, clarity, and logical rigor. Understanding verificationism provides insight into both the strengths and limitations of early 20th-century attempts to define the scientific method and draw clear distinctions between science and other forms of human thought.

## 2.2.4 Karl Popper

- Popper was deeply concerned with the question: What makes science different from other forms of knowledge?

Karl Popper was one of the most influential philosophers of science in the twentieth century. He was born in Vienna, Austria, in 1902 and grew up in a time of significant change in science and philosophy. He studied mathematics, physics, psychology, and philosophy at the University of Vienna, where he was deeply influenced by both the scientific advances of his time and the political events unfolding around him. His philosophical career was launched with the publication of his famous book, *The Logic of Scientific Discovery*, in 1934. Over the years, he produced several other notable works, including *The Poverty of Historicism*, *The Open Society and Its Enemies*, and *Unended Quest*. Popper was deeply concerned with the question: What makes science different from other forms of knowledge? He noticed that many claims, especially in fields such as astrology or psychoanalysis, seemed to explain everything but could never be tested in a clear and meaningful manner. In contrast, scientific theories, such as those of Einstein, made bold predictions that could be tested and possibly shown to be incorrect.

- Popper believed that the characteristics of being proven wrong were what made science unique

Popper believed that the characteristics of being proven wrong were what made science unique. His interest in this problem led him to propose a new approach to explaining science, one that focused on testing and criticism rather than confirmation and certainty. He also challenged the traditional idea of induction, which posits that science begins with observations and builds up to theories through generalisation. Popper argued that observations are never neutral or theory-free. Instead, scientists always start with some ideas, expectations, or background knowledge that influence what they observe and how they interpret it. For Popper, science begins not with observation, but with problems and questions. Scientists create bold guesses or hypotheses to answer these problems, and then they test these ideas carefully. This critical and dynamic view of science stood in sharp contrast to the more rigid and linear models that came before.

Popper's work was not just about science in the narrow sense but had broader implications for society and politics. In his book *The Open Society and Its Enemies*, he defended liberal democracy and criticised totalitarian ideologies. He argued that just as science progresses by being open to criticism and change, societies should also remain open, critical, and adaptable. According to Popper, dogmatism and absolute certainty, whether in science or politics, are dangerous. He

- For Popper, dogmatism and absolute certainty, whether in science or politics, are dangerous

believed in an open society where ideas could be debated freely and where progress came through learning from mistakes. Popper remained an active thinker and writer throughout his life, and his ideas continue to influence not just the philosophy of science but also education, politics, and critical thinking in general. He died in 1994, but his ideas remain strong. His work tells us that science is not about certainty, but about being honest enough to question our beliefs and brave enough to change them when necessary. This attitude of openness, humility, and critical inquiry is central to Popper's vision of both science and human progress.

## 2.2.5 Hypothetico-Deductivism

- Hypothetico-deductivism maintains that scientific theories are derived from imaginative guesses or hypotheses

Hypothetico-deductivism is a model of scientific reasoning proposed as an alternative to the traditional inductive method. While the inductive model suggests that scientific knowledge originates from pure, theory-free observations and then progresses to general theories, hypothetico-deductivism contrasts this idea. Hypothetico-deductivism maintains that scientific theories are not derived from observations, but rather are imaginative guesses or hypotheses created by scientists. These hypotheses are then tested through observations and experiments. Karl Popper, the key advocate of hypothetico-deductivism, argued that observations are never completely free from theory. He rejected the inductive idea that we can start with neutral observations and build theories from them. Instead, Popper believed that all observations are influenced by prior knowledge, expectations, or theoretical frameworks.

- No matter how many times a theory is tested and found consistent with observations, it can never be conclusively proven

According to Karl Popper, scientific theories are not specific or final truths; instead, they are bold speculations that can always be tested and potentially refuted. In the hypothetico-deductive model, the scientific process begins with a problem or question. A scientist proposes a hypothesis as a possible solution. From this hypothesis, logical consequences or predictions are deduced. These predictions are then compared with actual observations or experimental results. If the predictions are confirmed, the theory survives the test for the time being, but it is not proven to be true. If the predictions fail, the theory is considered falsified or in need of revision. This model emphasises the tentative nature of scientific knowledge. No matter how many times a theory is tested and found consistent with observations, it can never be conclusively proven. A single counterexample is enough to refute the theory. For example, seeing many black crows does not prove that all crows are black, but seeing one white crow is enough to falsify that claim. This approach reflects Popper's belief that science progresses by eliminating false theories and replacing them with better ones.

Hypothetico-deductivism also offers a new perspective on objectivity in science. Instead of relying on the idea of pure, theory-free observations, Popper emphasised intersubjective testability. This means that scientific claims should be testable by different people in different situations using a shared method. Science is objective, not because it starts from unbiased observations, but because it relies on public, testable procedures that anyone can repeat. Popper also suggested that observations are relatively, not absolutely, theory-dependent. While an observation might depend on some prior theory, it can still be used to test a different theory. This allows for a kind of flexibility in scientific testing. Popper associated the relationship between theory and observation with the age-old question: which came first, the chicken or the egg? Just as there is no final answer to that, in science, theory and observation are interdependent; each relates to and shapes the other. Hypothetico-deductivism claims that science moves forward not by proving theories, but by testing and refining them through critical, public, and repeatable methods.

- Hypothetico-deductivism claims that science moves forward not by proving theories, but by testing and refining them

## 2.2.6 Falsificationism

Falsificationism, proposed mainly by Karl Popper, is a central concept in his philosophy of science. It offers a distinctive explanation of how scientific knowledge evolves, challenging earlier models such as inductivism and verificationism. While traditional approaches emphasised confirmation through repeated observations, Popper argued that scientific theories should instead be judged by their capacity to be proven false. Inductivism maintained that scientific knowledge is built by collecting numerous observations and generalising patterns from them. However, this method faces a critical problem; no matter how many confirming observations are made, they cannot conclusively establish a universal law. For instance, observing thousands of white swans does not rule out the possibility of a black swan.

- For Popper, scientific theories should be judged by whether they can be proven false

Verificationism, developed by logical positivists, held that statements are meaningful only if they can be verified through direct experience or logical proof. Yet, this approach excludes many important scientific hypotheses that cannot be verified but remain testable in principle. To address these limitations, Popper introduced the concept of falsifiability as the hallmark

- According to falsificationism, a theory is scientific only if it makes bold, precise predictions that can be empirically tested and potentially refuted

of a scientific theory. According to falsificationism, a theory is scientific only if it makes bold, precise predictions that can be empirically tested and potentially refuted. For example, the claim 'All metals conduct electricity' is scientific because it can be tested and potentially disproven by finding a metal that does not conduct electricity. In contrast, theories that are vague, flexible enough to accommodate any outcome, or immune to empirical testing, such as astrology or Freudian psychoanalysis, lack scientific

- Falsificationism emphasizes that science progresses by a process of inferences and refutations

Falsificationism emphasises that science progresses not by accumulating confirmations, but by a process of inferences and refutations. Theories are proposed boldly and tested rigorously. Those that fail empirical tests are discarded, and better ones are developed in their place. This method promotes a dynamic and self-corrective model of scientific inquiry. Popper also noted a logical asymmetry: while a single counterexample can falsify a theory, no amount of supporting evidence can conclusively prove the theory to be true.

- The strength of falsificationism lies in its commitment to objectivity and openness

An essential strength of falsificationism lies in its commitment to objectivity and openness. Scientific claims must be publicly testable, allowing any competent observer to attempt replication or refutation, regardless of personal beliefs or backgrounds. This makes science a transparent and collaborative endeavour, rather than a speculative or dogmatic one. Falsificationism shifts the focus of science from proving theories right to testing them honestly and revising them in light of new evidence. It encourages critical thinking, intellectual humility, and the continuous refinement of knowledge. Popper's model remains influential for its clarity, its emphasis on learning through error, and its insistence on rational, testable inquiry as the foundation of scientific progress.

## 2.2.7 Verisimilitude

- The term 'verisimilitude' means 'closeness to truth'

Verisimilitude is a concept introduced by Karl Popper to explain how science progresses, even though we can never be absolutely certain that a scientific theory is true. The term 'verisimilitude' means 'closeness to truth' (very similar to truth) or 'approximation to truth.' Since Popper rejected the idea that science can prove theories to be true, he needed a way to describe how some theories can still be better than others. Verisimilitude is his answer to this problem. According to Popper, although we may never reach the absolute truth, we can still compare different scientific theories to see which one gets closer to it. A theory that explains more facts, makes more accurate predictions, and withstands more tests is considered to have greater verisimilitude. This helps scientists choose between competing theories even when none of them can be proven entirely true.

- Popper attempted to devise a logical method for assessing the proximity of a theory to the truth

For instance, Newton's theory of gravity was once accepted as the best explanation for how objects move. Later, Einstein's general relativity theory demonstrated that Newton's theory was not entirely accurate, particularly in extreme conditions, such as those found in powerful gravitational fields. However, Newton's theory remains effective in most everyday situations. Popper would argue that Einstein's theory has greater verisimilitude than Newton's because it explains more and aligns more closely with reality, even though neither theory can be considered the ultimate truth. Popper attempted to devise a logical method for assessing the proximity of a theory to the truth by comparing the true and false components of various theories. However, this turned out to be very difficult. Later philosophers showed that Popper's original idea had some flaws and could lead to surprising results. Still, the core idea of verisimilitude is essential. It reflects how science works; not by finding perfect truth, but by slowly improving theories to make them more accurate and helpful.

- Although we can never be entirely certain that a theory is accurate, we can say that some theories are closer to the truth than others

Verisimilitude also encourages a humble attitude in science. Scientists should always be aware that their theories are not final and must remain open to new evidence and better explanations. This idea fits well with Popper's broader philosophy of science, which emphasises critical thinking, openness to criticism, and learning through trial and error. Although we can never be entirely certain that a theory is accurate, we can say that some theories are closer to the truth than others. This idea supports the continuous improvement of scientific knowledge and highlights the importance of honest testing, comparison, and revision in the scientific process.



## Summarized Overview

The scientific method emphasises objectivity, repeatability, and logical reasoning. It seeks not only to collect facts but to discover general laws that explain natural phenomena. Two major approaches to scientific reasoning are inductivism and hypothetico-deductivism. Inductivism builds theories based on repeated and consistent observations, assuming that general rules can be drawn from them. However, this method faces the problem of induction; it cannot guarantee that future cases will follow past patterns. In contrast, hypothetico-deductivism, as advanced by Karl Popper, begins with hypotheses that are critically tested. It shifts the focus from certainty to continuous testing and improvement, recognising that scientific knowledge is always open to revision.

Another vital contribution to the philosophy of science is positivism, which posits that true knowledge can only come from direct observation and logical proof. Thinkers like Auguste Comte and the thinkers of the Vienna Circle argued that science should avoid untestable or speculative ideas. From this view came verificationism, which states that a sentence is meaningful only if it can be observed or logically proven. However, verificationism was criticised for being too narrow, as it excluded many significant scientific theories that could not be directly verified. Critics also pointed out that observation is not always neutral; it is influenced by prior knowledge and expectations. These criticisms led to further developments in the understanding of scientific reasoning.

Karl Popper's theory of falsificationism responded to these challenges by suggesting that scientific theories should be judged by whether they can be tested and possibly disproved. A theory that cannot be falsified is not scientific. This approach supports a view of science as a process of trial and error, where theories are proposed boldly and tested rigorously. Popper also introduced the concept of verisimilitude, meaning 'closeness to truth.' Even if absolute truth is unreachable, some theories are closer to it than others because they explain more and withstand more testing. This idea reflects the dynamic and self-corrective nature of science. Together, these approaches help to explain how science grows; not by proving things with certainty, but by constantly testing, refining, and improving our understanding of the world.



## Self-Assessment

1. Compare and contrast inductivism and hypothetico-deductivism in the context of scientific reasoning.
2. Explain the problem of induction and its impact on the reliability of scientific knowledge.
3. What is positivism? How did Auguste Comte's three stages of human knowledge contribute to the development of this view?
4. Discuss the concept of verificationism and the reasons for its decline in the philosophy of science.
5. What does Karl Popper mean by falsifiability, and how does it help distinguish scientific theories from non-scientific ones?
6. Explain the concept of verisimilitude as introduced by Karl Popper. How does it help in explaining scientific progress?

## Assignments

1. Critically examine the philosophical foundations of the scientific method by analysing inductivism, hypothetico-deductivism, and falsificationism. How do these approaches influence the way science is practised today?
2. Critically examine the development of positivism and verificationism within the philosophy of science. How have these approaches shaped the understanding of meaningful knowledge in modern scientific inquiry, and what are the major criticisms they have faced?
3. Evaluate Karl Popper's contribution to the philosophy of science by examining the interconnected concepts of hypothetico-deductivism, falsificationism, and verisimilitude. How do these ideas collectively offer a logical framework for explaining scientific progress?

## Reference


1. Lakatos, I. (1970). Falsification and the Methodology of Scientific Research Programmes. In I. Lakatos & A. Musgrave (Eds.), *Criticism and the Growth of Knowledge* (pp. 91–196). Cambridge University Press.
2. Okasha, S. (2016). *Philosophy of Science: A Very Short Introduction* (2nd ed.). Oxford University Press.
3. Kuhn, T. S. (1996). *The Structure of Scientific Revolutions* (3rd ed.). University of Chicago Press.
4. Ladyman, J. (2002). *Understanding Philosophy of Science*. Routledge.
5. Chalmers, A. F. (2013). *What Is This Thing Called Science?* (4th ed.). Open University Press.
6. Hume, D. (2000). *An Enquiry Concerning Human Understanding* (T. Beau-champ, Ed.). Oxford University Press. (Original work published 1748)


## Suggested Reading


1. Lakatos, I. (1970). Falsification and the Methodology of Scientific Research Programmes. In I. Lakatos & A. Musgrave (Eds.), *Criticism and the Growth of Knowledge* (pp. 91–196). Cambridge University Press.
2. Bacon, F. (2000). *The New Organon* (L. Jardine & M. Silverthorne, Trans.). Cambridge University Press. (Original work published 1620).

3. Godfrey-Smith, P. (2003). *Theory and Reality: An Introduction to the Philosophy of Science*. University of Chicago Press.

4. Goodman, N. (1983). *Fact, Fiction, and Forecast* (4th ed.). Harvard University Press.

5. Popper, K. R. (2002). *The Logic of Scientific Discovery*. Routledge. (Original work published 1934).

## Space for Learner Engagement for Objective Questions

Learners are encouraged to develop objective questions based on the content in the paragraph as a sign of their comprehension of the content. The Learners may reflect on the recap bullets and relate their understanding with the narrative in order to frame objective questions from the given text. The University expects that 1 - 2 questions are developed for each paragraph. The space given below can be used for listing the questions.

# UNIT 3
# Lakatos's Revision of Popperian Falsificationism

## Learning Outcomes

Upon the completion of this unit, the learner will be able to:

- explain the core idea of Popper's falsificationism and identify its limitations in real scientific practice
- describe the key components of Lakatos's research programmes
- differentiate between progressive and degenerative research programmes using Lakatos's criteria
- explain the role of heuristics in guiding the development of scientific theories
- interpret the relevance of the Duhem–Quine thesis in Lakatos's model of theory testing and modification
- evaluate the contributions and criticisms of Lakatos's approach to scientific progress

## Background

Understanding how science changes over time is essential for grasping how knowledge in any field evolves and improves. Scientific theories are not just built on experiments and data, but are also shaped by deeper questions about how we judge their reliability, usefulness, and truth. Exploring the philosophy behind scientific change offers valuable insight into how theories survive challenges, adapt to new evidence, or are replaced by better explanations. This perspective is especially important in today's world, where science plays a central role in society, policy, and daily life. By examining how thinkers have tried to explain the logic and method behind scientific growth, it becomes easier to see science not as a fixed body of facts, but as a dynamic and self-correcting process. In this context, attention is given to Lakatos's revision of Popperian falsificationism, which presents a more realistic and flexible explanation of scientific progress.

## Keywords

Scientific progress, research programme, hard core, protective belt, heuristics, ad hoc modification, Duhem–Quine thesis, progressive research programme, degenerative research programme, Methodology of Scientific Research Programmes (MSRP)

## Discussion

### 2.3.1 Limits of Popper's Falsificationism

- For Popper, science advances by testing and falsifying bold theories

Karl Popper played a pivotal role in shaping twentieth-century philosophy of science through his concept of falsificationism. He argued that a theory is scientific not because it has been repeatedly confirmed, but because it can, in principle, be proven false. Popper emphasised that science progresses through bold conjectures and rigorous attempts to falsify them. If a theory withstands such testing, it gains credibility, though never absolute certainty. He introduced falsifiability as a solution to the demarcation problem, which is the challenge of distinguishing between scientific theories and non-scientific ones. Falsificationism was a powerful alternative to earlier models, such as inductivism and verificationism. It shifted the focus of science from the pursuit of certainty to the recognition of fallibility and the importance of critical testing.

- The Duhem–Quine thesis states that a scientific theory is never tested in isolation

Despite its strengths, falsificationism has faced significant criticism. Logically, it presents an overly simplistic view of how scientific theories are tested. Popper claimed that if a theory leads to a prediction that turns out to be false, the theory should be rejected. However, in real scientific practice, theories are rarely tested in isolation. They are tested alongside a network of background assumptions, auxiliary hypotheses, and measurement conditions. This idea is captured in the Duhem–Quine thesis, which states that a scientific theory is never tested in isolation; it is constantly tested in conjunction with a web of background assumptions and auxiliary hypotheses. Hence, it argues that a failed prediction does not clearly indicate which part of the theoretical system is responsible. As a result, when experimental results contradict predictions, scientists often re-examine their assumptions or the experimental setup, rather than rejecting the core theory outright. This makes the process of falsification more ambiguous than Popper suggested.

Falsificationism also struggles to clearly separate science from pseudoscience. A theory might be technically falsifiable yet still vague or weak, while more robust theories may resist falsification due to the complexity of the phenomena involved. Sometimes, even well-established theories yield incorrect predictions due to measurement errors or simplifying assumptions. In such cases, a strict falsificationist approach could lead to the premature dismissal of valuable scientific theories. Historically, science has not progressed strictly through falsification. Popper's student, Imre Lakatos, addressed these issues by proposing a more flexible and traditionally informed framework. Lakatos appreciated Popper's emphasis on critical testing but found his model too rigid and unrealistic.

- A strict falsificationist approach could lead to the dismissal of valuable scientific theories

For instance, Lakatos noted that major scientific theories, such as Newtonian physics, were not immediately abandoned when anomalies arose. A striking example is how nineteenth-century scientists responded to the irregularities in Mercury's orbit. Although Mercury's movement did not fully align with Newton's predictions, scientists continued to trust Newton's laws. Instead of rejecting them, they explored alternative explanations, such as an undiscovered planet or observational errors. They retained Newton's core theory and modified auxiliary assumptions until Einstein's general relativity provided a better explanation decades later. This historical episode demonstrates that scientific theories are often refined rather than discarded, challenging Popper's idea of strict falsification.

- In real context, theories like Newtonian physics are often refined, not rejected

Moreover, Popper did not provide a clear rule for when a theory should be rejected. Scientists are often reluctant to discard a theory after a single failed prediction. Even Popper's more refined model of sophisticated methodological falsificationism was, according to Lakatos, insufficient for explaining how theories are maintained despite apparent falsifying evidence. Another important issue concerns ad hoc modifications. Popper warned that making arbitrary adjustments to save a theory from falsification, i.e., ad hoc modifications, reduces its scientific value. However, in actual scientific practice, the line between unjustified ad hoc changes and legitimate refinements or improvements is not always clear. Science often requires creative and temporary adjustments to theories to make sense of complex data, and these may not always fit Popper's ideal model, but are still part of how science realistically works.

- One significant issue of falsificationism concerns ad hoc modifications

Additionally, critics have pointed out that Popper's falsificationism does not offer an adequate method for choosing between competing theories. Science values more than just falsifiability; criteria such as coherence, explanatory power, simplicity, and fruitfulness are also significant. Popper's emphasis on testability does not fully capture the qualitative judgments that scientists use when evaluating theories. Theories like psychoanalysis or Marxism, which Popper considered pseudo-scientific because they could explain everything and therefore could not be falsified, resist easy classification under the falsifiability criterion. However, such theories have still played essential roles in intellectual history, despite lacking clear refutability. Popper's falsificationism introduced a necessary emphasis on testability and critical rationalism in science, though it faces substantial limitations in light of real scientific practice. Scientific reasoning is more flexible, complex, and context-dependent than Popper's model allows. To address these concerns, Popper's student, Imre Lakatos, developed the Methodology of Scientific Research Programmes (MSRP).

- Falsificationism lacks a clear way to choose between competing theories

## 2.3.2 Lakatos's Methodology of Scientific Research Programmes (MSRP)

Lakatos proposed the Methodology of Scientific Research Programmes (MSRP) as an alternative to Popper's falsificationism and Kuhn's model of paradigm shifts. While he admired Popper's commitment to rationality, he criticised falsificationism for its lack of historical realism. At the same time, he rejected Kuhn's depiction of scientific change as a non-rational leap between paradigms—broad, guiding frameworks of normal science. According to Kuhn, science undergoes revolutions when anomalies accumulate and can no longer be resolved within the existing paradigm. Lakatos found this account insufficiently rational, as it lacked objective criteria for comparing competing theories. His MSRP sought to bridge this gap by integrating Popper's rationalist ideals with Kuhn's historical insights, portraying scientific progress as a competition among structured research programmes rather than through isolated falsifications or abrupt paradigm shifts.

- MSRP of Lakatos blends Popper's rationalist ideals with Kuhn's historical insights

In Popper's falsificationism, scientific theories are tested one by one or in isolation and are supposed to be rejected if they are falsified by observations. However, Lakatos noted that in real scientific practice, scientists do not usually discard a theory immediately when faced with conflicting evidence. This inspired Lakatos to shift the focus from individual theories to what he called research programmes. He argued that scientific activity is better understood not as isolated attempts to prove or disprove single theories, but as long-term research efforts

- For Lakatos, each research programme is composed of a 'hard core' and a 'protective belt.'

centred around a series of related theories that evolve. Each research programme, according to Lakatos, is composed of a 'hard core' and a 'protective belt.' The hard core consists of the central theoretical assumptions that scientists working within the programme accept as given. These core ideas are not easily questioned or abandoned. Around this hard core lies the protective belt of auxiliary hypotheses, which are more flexible and can be modified in response to anomalies or new findings.

- Positive heuristic guides the development of new ideas to advance the programme

For example, in Newtonian mechanics, the hard core includes Newton's laws of motion and universal gravitation. In contrast, the protective belt includes additional assumptions related to measurement, celestial bodies, and atmospheric interference. The key feature of Lakatos's model is that it adjusts the protective belt to defend the core. However, this process is not arbitrary. Lakatos emphasised the importance of what he called 'heuristics' in guiding the development of the research programme. Heuristics are the guiding principles or strategies that scientists follow when developing and modifying a research programme. The negative heuristic tells scientists not to question the core, while the positive heuristic encourages them to develop new auxiliary hypotheses, models, and explanations to extend and improve the programme.

- Scientific progress occurs when a research programme is 'progressive.'

Scientific progress, in Lakatos's view, occurs when a research programme is 'progressive.' A progressive research programme predicts new facts, explains more phenomena, and leads to the discovery of novel evidence. It shows both theoretical progress (by refining and expanding the framework) and empirical progress (by making predictions that are later confirmed). By contrast, a 'degenerating' research programme fails to produce new knowledge or only responds to criticism by making ad hoc adjustments that do not lead to discoveries. A degenerative programme often struggles to explain the facts it was once able to handle and offers no fruitful direction for further investigation.

An essential aspect of Lakatos's MSRP is that it provides a way to compare and judge competing research programmes. Instead of focusing on isolated falsifications, Lakatos emphasised the long-term development of theory and empirical success. When two research programmes compete, the better one is the more progressive one. However, Lakatos acknowledged that scientists may continue working within a degenerating programme in the hope that it will recover, especially if there is no strong progressive alternative available at the time. Lakatos's model also offers a response to Kuhn's idea of scientific revolutions. While Kuhn described paradigm shifts as irrational or non-logical changes in worldviews, Lakatos sought to preserve rationality in the process of theory change. He accepted that science is influenced by historical and social contexts but insisted that rational evaluation is still possible through the comparison of research programmes over time. Unlike Kuhn's incommensurable paradigms, Lakatos's research programmes can coexist and be evaluated on shared standards of progress.

- Lakatos emphasised the long-term development of theory instead of isolated falsifications

Lakatos addressed another issue that Popper struggled with: the ad hoc modification of theories. Popper warned that making arbitrary adjustments to save a theory from falsification weakens its scientific status. However, in practice, distinguishing between unjustified ad hoc changes and legitimate refinements is not always easy. Science often requires temporary and creative modifications to interpret complex data. Lakatos's framework accommodates this by judging theories based on the progressive or degenerative nature of the research programme to which they belong.

- In practice, it is hard to separate unjustified ad hoc changes from valid refinements

Ultimately, Lakatos's model addresses criticisms that Popper's falsifiability criterion alone is insufficient for evaluating scientific theories. Science also values explanatory power, simplicity, coherence, and fruitfulness. While Popper's falsificationism brought valuable emphasis on testability and rational criticism, it does not fully capture the complexity of scientific practice. Scientific reasoning is more flexible, historically informed, and context-dependent than Popper's model allows. Lakatos's Methodology of Scientific Research Programmes offers a richer, more balanced view of how science evolves through structured research programmes that adapt, grow, and compete over time.

- Science also values explanatory power, simplicity, coherence, and fruitfulness

## 2.3.3 Lakatos's View of Scientific Progress

In Imre Lakatos's view, scientific progress is best understood not through isolated theories or sudden revolutions, but through the ongoing development of research programmes. Each programme contains a central set of ideas, the hard core, which is protected by a belt of auxiliary hypotheses. These surrounding assumptions can be adjusted in response to new data, while the core remains stable. Another essential idea Lakatos builds upon is the Duhem–Quine thesis, which suggests that

- For Lakatos, scientific progress involves adjusting auxiliary assumptions while preserving core ideas no theory is tested in isolation. Scientific tests always involve background assumptions, so a failed prediction does not mean the whole theory must be rejected. Instead, scientists often revise parts of the protective belt to accommodate unexpected results. This indicates that theory rejection is not immediate, but rather involves thoughtful revision.

- Lakatos emphasised heuristic power as key to scientific progress

Another key feature of Lakatos's model is heuristic power, the ability of a research programme to guide scientists in creating new ideas, solving problems, and extending knowledge. The positive heuristic leads researchers to explore new directions, while the negative heuristic prevents them from challenging the core assumptions too quickly. For Lakatos, a progressive research programme increases both theoretical explanation and empirical success. It explains more, predicts new phenomena, and continues to grow. In contrast, a degenerative programme only makes reactive changes to avoid failure, without generating new knowledge. Lakatos illustrated this with the example of Newtonian physics, which initially advanced by using tools like calculus to explain planetary motion. Its strength lay in its ability to evolve through internal refinements and successful predictions.

- Lakatos's idea of scientific progress is a dynamic and rational process

Lakatos described the development of science as a kind of 'war of attrition' between different research programmes. This means that science advances through long-term competition between programmes. Those that are better at solving problems and making successful predictions gradually become stronger, while others that fail to do so slowly lose importance. This view presents scientific progress as a steady and organised process, not as something that happens suddenly or through a single event. However, Lakatos's model has also faced some criticism. Philosopher Paul Feyerabend pointed out that Lakatos did not clearly explain how to decide when a degenerating programme should be given up. He also felt that Lakatos chose historical examples that supported his own theory and ignored others, making the model seem more straightforward than the real history of science, which is often messy and unpredictable. In short, Lakatos's idea of scientific progress is a dynamic and rational process. It involves the continuous testing and improvement of research programmes guided by heuristics and measured by their long-term success in explaining and predicting phenomena.

## Summarized Overview

Scientific knowledge is not static; it evolves and improves over time. One major explanation for how science progresses was proposed by Karl Popper, who argued that a theory is scientific only if it can be tested and potentially proven false, a view known as falsificationism. While influential, this approach was often too rigid to match the way science actually operates. Imre Lakatos, the student of Popper, responded by offering a more flexible and realistic model known as the Methodology of Scientific Research Programmes (MSRP). According to this view, science advances through organised research programmes that are built around a central set of ideas, called the hard core, which remains protected, while other parts, called the protective belt, can be modified to accommodate new evidence or address problems. Lakatos introduced the concepts of positive and negative heuristics to guide the process of making these changes. A programme is considered progressive if it leads to new discoveries and predictions, and degenerative if it only adjusts itself to avoid failure without producing fresh insights. This perspective offers a more accurate picture of how scientific theories evolve in response to both logical reasoning and historical developments. It also invites reflection on how competing theories are evaluated and why some persist while others are eventually set aside.



## Self-Assessment

1. What are the major criticisms of Popper's model of scientific progress?
2. Define the terms hard core and protective belt in Lakatos's research programme.
3. Distinguish between progressive and degenerative research programmes with examples.
4. What is the significance of the Duhem–Quine thesis in the context of Lakatos's theory?
5. Explain the role of positive and negative heuristics in guiding scientific research.

## Assignments

1. Critically examine Lakatos's Methodology of Scientific Research Programmes (MSRP) as a response to the limitations of Popper's falsificationism.
2. Discuss the differences and similarities between Popper, Kuhn, and Lakatos in their views on scientific change.
3. 'Scientific progress is not a series of abrupt revolutions but a competition between evolving research programmes.' Discuss with reference to Lakatos's contributions.

## Reference


1. Lakatos, I. (1970). Falsification and the Methodology of Scientific Research Programmes. In I. Lakatos & A. Musgrave (Eds.), *Criticism and the Growth of Knowledge* (pp. 91–196). Cambridge University Press.
2. Okasha, S. (2016). *Philosophy of Science: A Very Short Introduction* (2nd ed.). Oxford University Press.
3. Kuhn, T. S. (1996). *The Structure of Scientific Revolutions* (3rd ed.). University of Chicago Press.
4. Ladyman, J. (2002). *Understanding Philosophy of Science*. Routledge.
5. Chalmers, A. F. (2013). *What Is This Thing Called Science?* (4th ed.). Open University Press.
6. Hume, D. (2000). *An Enquiry Concerning Human Understanding* (T. Beauchamp, Ed.). Oxford University Press. (Original work published 1748)


## Suggested Reading


1. Lakatos, I. (1970). Falsification and the Methodology of Scientific Research Programmes. In I. Lakatos & A. Musgrave (Eds.), *Criticism and the Growth of Knowledge* (pp. 91–196). Cambridge University Press.
2. Bacon, F. (2000). *The New Organon* (L. Jardine & M. Silverthorne, Trans.). Cambridge University Press. (Original work published 1620).
3. Godfrey-Smith, P. (2003). *Theory and Reality: An Introduction to the Philosophy of Science*. University of Chicago Press.
4. Goodman, N. (1983). *Fact, Fiction, and Forecast* (4th ed.). Harvard University Press.
5. Popper, K. R. (2002). *The Logic of Scientific Discovery*. Routledge. (Original work published 1934).

## Space for Learner Engagement for Objective Questions

Learners are encouraged to develop objective questions based on the content in the paragraph as a sign of their comprehension of the content. The Learners may reflect on the recap bullets and relate their understanding with the narrative in order to frame objective questions from the given text. The University expects that 1 - 2 questions are developed for each paragraph. The space given below can be used for listing the questions.

# BLOCK 3
# Progress in Science

# UNIT 1
# Thomas Kuhn: Progress in Science

## Learning Outcomes

By the end of this unit, the learner will be able to:

- explain the Enlightenment view of science
- explain how Kuhn redefines progress not as the accumulation of truths but as a transformation in frameworks of explanation
- explain how Kuhn's concepts of paradigm, paradigm shift, and incommensurability challenge the rationality traditionally attributed to science
- contrast Kuhn's historical and sociological explanation of science with the logical structure of science in positivism
- critically evaluate the non-cumulative nature of scientific progress

## Background

The idea that history, especially the history of science, is linear and progressive has been a dominant theme since the Enlightenment. Enlightenment thinkers envisioned scientific advancement as a steady march toward truth, replacing ignorance and superstition with reason, empirical evidence, and universal laws. In this view, each scientific discovery is seen as an "add-on" to previous knowledge, making scientific development cumulative. From Newtonian mechanics to quantum theory, science has often been portrayed as a rational, objective enterprise that continuously builds upon itself to offer an increasingly accurate picture of reality and a better world through technological and social progress. However, this narrative has been critically examined by 20th-century philosophers of science, particularly through the critiques of Thomas Kuhn and Paul Feyerabend. For them, science is not strictly a rational enterprise but a social activity conducted within a scientific community. They argue that scientific development is not always linear or cumulative but often cyclical and revolutionary. Kuhn's concept of "paradigm shifts" suggests that scientific revolutions occur when existing frameworks fail to explain anomalies, leading to the replacement of one paradigm by another, often with entirely different assumptions, methods, and values. This challenges the idea of continuous progress.

## Keywords

Paradigm, Paradigm shift,Scientific revolution,Non-cumulative, Progress

## Discussion

- Science functions within a shared framework maintained by a scientific community

Thomas S. Kuhn (1922—1996), philosopher and historian of science, posed a powerful philosophical challenge to traditional assumptions about how science functions and progresses. He argued that scientific inquiry is not conducted in a vacuum but within established theoretical frameworks, which he termed 'paradigms'. A paradigm consists of a core scientific theory surrounded and supported by a number of auxiliary hypotheses. The core theory generally remains constant, whereas the auxiliary hypotheses are modified in light of new or conflicting evidence.

- A paradigm shift occurs due to persistent anomalies

The paradigm can be loosely called 'normal science'. It shapes what Kuhn called normal science, where routine problem-solving activities occur, guided by shared assumptions and methodologies within the scientific community. However, when persistent anomalies and inconsistencies arise in a way that the existing paradigm cannot explain, they may lead to a scientific revolution, resulting in a paradigm shift, where one theoretical framework is replaced by another. A significant point is that every normal-scientific tradition emerges from a scientific revolution. This is the revolutionary argument Kuhn presents in his famous book *The Structure of Scientific Revolutions* (1962).

- Science cannot be exemplified by the observations, laws, and theories in the classics
- Science can be exemplified only by the historical record of the research activity

Kuhn (1962) emphatically uncovers the central role of history in explaining scientific activity and research, and the need for viewing history as a repository for more than anecdotes or chronology. He observes in the first chapter of the book "Introduction: A Role for History": "History, if viewed as a repository for more than anecdote or chronology, could produce a decisive transformation in the image of science by which we are now possessed." According to him, it is from the view that history is a list of isolated stories or a repository of achievements that we wrongly possess an image of science as finished scientific theories or achievements as recorded in the classics. He explains how the polished results or the 'unhistorical stereotype' drawn from the classics or textbooks present science as a straightforward, rational, cumulative process. He rejects the prevalent textbook image of science that the content of science is "uniquely exemplified by the observations, laws, and theories described in their pages" and puts forth a different concept of science that "can emerge from the historical record of the research activity itself."

- Science is not a linear and cumulative process

Kuhn's central claim is that scientific development is not a linear, cumulative accumulation of knowledge. Instead, it unfolds through a series of paradigm shifts, each of which fundamentally changes the scientific field. New paradigms do not simply build on the old but replace them, altering the basic concepts, methods, and standards of the discipline.

- Kuhn challenges the Enlightenment concept of science

The Enlightenment presented science and its hallmark method as definitive of rational life. Science was understood as a rational, objective, and cumulative enterprise that steadily uncovers truths about the natural world. Progress was understood as linear, each theory building upon and refining its predecessor, leading to an ever-improving explanation of reality. The Enlightenment, shaped by the intellectual and scientific advances of the 16th and 17th centuries, held the conviction that reason, empirical inquiry, and the scientific method could liberate humanity from ignorance, superstition, and religious dogma. Science was thus seen as a force to demystify the world, stripping away mythological and theological narratives in favour of observable, testable knowledge. The scientific explanations aimed to replace the mythological narratives. With the advent of the Industrial Revolution, science became synonymous with progress, and it was venerated as being the peculiarly modern way of thinking.

- The Enlightenment view of science was reinforced by logical positivism

The image of science as a rational, cumulative, and linear enterprise, first developed during the Enlightenment, was later reinforced and formalised by the philosophical movement of logical positivism in its attempt to give science a rigorous philosophical foundation. Logical positivism focused on empirical verification, logical structure, and the unity of science, reinforcing the idea that scientific progress is rational, methodical, and accumulative. It is this view that Kuhn attacked while presenting a different conception of science, which is non-linear, discontinuous, and shaped by deep conceptual ruptures, rather than the steady accumulation of facts and knowledge.

## 3.1.1 Kuhn and the Structure of Scientific Development

- Pre-science — normal science — crisis — revolution — new normal science — new crisis

According to Kuhn, the structure of scientific development, or the way science progresses, follows an open-ended pattern broadly outlined in four stages: pre-paradigm science → normal science → extraordinary science → new normal science. In *What is This Thing Called Science*, Alan Chalmers (2013) summarises Kuhn's picture of scientific progress in the following way: Pre-science — normal science — crisis — revolution — new normal science — new crisis.

- Normal science is where there is a consensus around a single paradigm

The pre-paradigm phase is where scientists work with different approaches, without any consensus or agreement within a scientific community. In this phase, there is no unified framework to guide the research, and thus science is considered immature. The second phase is that of normal science, where the scientific community reaches a consensus around a single paradigm. Kuhn observes this as the transition from immature to mature science, where researchers engage in problem-solving within the shared framework.

- A paradigm consists of the general theoretical assumptions and laws.
- A paradigm is the general worldview upheld by the scientific community

The disorganised and diverse activities before the formation of science in the pre-paradigm phase become structured and directed when the scientific community adheres to a single paradigm. A paradigm, according to Chalmers (2013), "is made up of the general theoretical assumptions and laws and the techniques for their application that the members of a particular scientific community adopt." It is almost synonymous with a scientific community, warranting both logical and physical closeness. In other words, it is a worldview of the scientific community, such as Aristotelian physics, Copernican astronomy, Newtonian physics, Ptolemaic astronomy, particle physics, quantum physics, etc.

- Normal science does not aim for novelty but for puzzle-solving within established frameworks

In the paradigm, scientists practise what Kuhn calls 'normal science', which is characterised by puzzle-solving within established frameworks, methodological consensus, and avoidance of foundational critique. As Ian Hacking (2013) puts it in the preface to the Structure: "Normal science does not aim at novelty but at clearing up the status quo. It tends to discover what it expects to discover." A normal scientist ignores the anomalies; otherwise, she cannot carry on with her research, as Kuhn observes: "The scientist who pauses to examine every anomaly he notes will seldom get significant work done."

Paradigms are not merely frameworks within which science operates; they are constitutive of science, of meaning, and of the subject matter of discourse. This means that each paradigm defines its own distinctive set of problems, methods, and standards of solution, which may not be identified as such in a different paradigm. As Kuhn (2013) says, scientists in different paradigms may "disagree about what is a problem and what is a solution; they will inevitably talk through each other when debating the relative merits of their respective paradigms." Additionally, paradigms determine the meanings of the terms used in scientific theories, and each paradigm maintains a strong consensus-thinking. Kuhn insists on strict adherence to the paradigm on the part of the scientists. In Ladyman's view, scientists would do anything to be faithful to the paradigm "even in the face of contradictory evidence."

- Each paradigm has its own distinct set of problems, methods, and solutions

The shift from normal science to extraordinary science occurs when unresolved anomalies accumulate, forcing some scientists to question the paradigm itself. Anomalies are the irregularities or inconsistencies that the current paradigm cannot adequately explain. At this point, according to Kuhn (2013), the discipline of science enters a period of crisis characterised by "a proliferation of compelling articulations, the willingness to try anything, the expression of explicit discontent, the recourse to philosophy, and debate over fundamentals." The crisis develops when the scientific community identifies that the ruling paradigm is unable to account for the accumulating anomalies.

- Strong irregularities and inconsistencies force scientists to question the paradigm

The crisis forces the scientific community to practise 'extraordinary science' in which they resolve the anomalies. In resolving the crisis, scientists question the fundamental assumptions and seek radical solutions. The crisis is then resolved through a scientific revolution (a new theoretical framework) in which the community selects a new paradigm by replacing the old one, as the heliocentric paradigm replaced the geocentric one. Once a paradigm is sufficiently weakened and undermined and loses the confidence of its proponents, the time is ripe for a scientific revolution. The scientific revolution or paradigm shift then becomes complete, functioning as the new normal science. The cycle from normal science to new normal science through revolution is free to occur again.

- After a scientific revolution, the newly established paradigm becomes the basis for normal science

Scientific revolutions are fundamental changes in worldview, and the world changes in revolutions. Kuhn (2013) states that when past scientific research is examined from the vantage point of contemporary historiography, historians of science may be tempted to think that "when paradigms change, the world itself changes with them. Led by a new paradigm, scientists adopt new instruments and look in new places. Even more importantly, during revolutions, scientists see new and different things when looking with familiar instruments in places they have looked before."

### 3.1.2. Incommensurability: The Limits of Rational Comparison

- Paradigms are incommensurable: mutually exclusive ways of seeing the world

Kuhn uses the phrase 'incommensurability' of frameworks to indicate the communication breakdown arising during the period of scientific revolution. The incommensurability of two paradigms is something more than incompatibility and happens due to the rejection of an old theory, changes in the scientific field, changes in terms, concepts, experiments, and the tools and techniques used, as well as standards of solution.

- One framework is not more 'true' compared to another

For example, scientists in the geocentric paradigm and the heliocentric paradigm may observe and theorise about the centre of the universe, while the centre means entirely different realities for both. Kuhn (2013) observes that the differences between various scientific schools are not due to one or another failure of method; they were all 'scientific'; rather, "their incommensurable ways of seeing the world and of practising science in it." In other words, incommensurability raises the debate over whether one scientific framework can be regarded as more 'true' compared to another and whether scientific progress represents a movement toward truth or merely a shift in perspective and approach. Kuhn affirms that scientific progress is not a cumulative movement towards truth.

- Tension between being an inventor and a faithful traditionalist.

Kuhn discusses a fundamental tension in the way science is conducted within a paradigm. A scientist essentially needs flexibility and open-mindedness, which imply divergent thinking from tradition, to progress; at the same time, 'convergent thinking' and rootedness in the existing tradition are also crucial: "Only investigations firmly rooted in the contemporary scientific tradition are likely to break that tradition and give rise to a new one." Thus, an essential tension arises over a scientist being an enthusiastic innovator or inventor and a faithful traditionalist at the same time.

### 3.1.3 Noncumulative Process: Kuhn on the Progress of Science

Kuhn's radical proposal regarding scientific development and the concept of paradigm shift must be understood in

- Kuhn challenges the verificationist account of scientific development

relation to the historical context he responded to. Verificationism, the key idea of logical positivism developed by the Vienna Circle in the 1920s, held that a statement or theory is scientific only if it can be empirically verified, that is, if there is a way to test it through positivist methods, observation, and experiment. In this logical positivist approach to science, verification played a significant role in developing the criterion of demarcation, a way to distinguish science from non-science, such as metaphysics and pseudo-science.

- Kuhn's challenge against confirmationism, a moderate principle of logical positivism

However, the logical empiricists' later works abandoned the verifiability criterion of meaning and instead emphasised the importance of empirical confirmation of scientific theories. The strict version of verificationism encountered practical difficulties. Most scientific statements, especially universal laws like "all metals expand when heated," could not be conclusively verified but were still considered scientifically valid. In response, logical empiricists like Rudolf Carnap abandoned the verifiability criterion of meaning and developed a more flexible version known as confirmationism in their mission to differentiate between statements that genuinely convey something (scientific) and statements that are empty verbiage and have no meaning (metaphysics).

- Verificationism and confirmationism: Science advances through the accumulation of confirming instances that support an existing theory

Carnap (2011) opted for a form of partial verification that he called 'confirmation.' According to the confirmation principle, an increase in the number of positive instances of a law makes the law stronger: "If in the continued series of such testing experiments no negative instance is found but the number of positive instances increases, then our confidence in the law will grow step by step." According to this principle, scientific theories are not strictly verified but rather confirmed by an increased number of consistent empirical evidence. That is, confirmation by empirical data increases the degree of rational belief in the hypothesis, thereby strengthening confidence in the scientific law. The fundamental idea behind verificationism and confirmationism is that science advances through the accumulation of confirming instances that support a theory, rather than through final proofs. These principles uphold that scientific progress is linear and cumulative and that scientists' fundamental task is to collect as much empirical data through observation to support and strengthen an already existing theory.

However, Karl Popper rejected the verificationist and confirmationist accounts of how science functions and how scientific progress is understood. He argued that verification and confirmation do not offer a satisfactory criterion of

- Falsificationism: Science advances by proposing bold theories that are testable and open to being proven false

demarcation, nor do they help us meaningfully explain how science progresses. According to Popper, scientific progress does not occur by verifying theories or merely accumulating supporting empirical data. Instead, it advances through the formulation of bold hypotheses that are subjected to rigorous attempts at falsification via carefully designed experiments and observations. A theory is considered scientific—and progressive, in contrast to religious or metaphysical claims—only if it is open to the possibility of being proven false. This continual openness to falsification is what, for Popper, distinguishes genuine sciences like physics from non-scientific disciplines such as metaphysics.

- Different accounts of the progress of science

Alan Chalmers (2013) describes the concept of advances in science from the falsificationist perspective: "The falsificationist, by contrast, recognises the limitation of induction and the subservience of observation to theory. Nature's secrets can only be revealed with the aid of ingenious and penetrating theories. The greater the number of conjectured theories that are confronted by the realities of the world, and the more speculative those conjectures are, the greater will be the chances of major advances in science." Chalmers affirms that the major difference between the positivist (inductivist) method and the falsificationist method is that while the former considers only those theories that can be shown to be true or probably true science, the latter encourages the proposal of bold speculative conjectures and creates a 'do or die' situation. On another occasion, he states Popper's stance: "It was urged that science should progress by the proposal of bold, highly falsifiable conjectures as attempts to solve problems, followed by ruthless attempts to falsify the new proposals. Along with this came the suggestion that significant advances in science come about when those bold conjectures are falsified."

- Kuhn's rejection of the falsificationist account of progress

As he rejected the positivist account of science, Kuhn also rejected the falsificationist view that significant advances in science occur through the falsification of bold conjectures. Science does not progress through testing and falsification. There is no such progress in science. Kuhn's criticism of falsificationism is related to the relationship between theory and observation. Like many others, Kuhn argues that observation is not neutral but is itself deeply theory-laden. What a scientist sees or interprets as data is often guided or shaped by the theoretical frameworks and assumptions they have already accepted. As a result, scientists who hold different theories (working within different paradigms) may report different or contradictory observations even when observing the same phenomenon.

- In different paradigms, the same phenomena can be observed differently based on distinct theoretical frameworks

For example, a physicist or astronomer trained in the geocentric framework (where the Earth is considered the centre of the universe) might genuinely observe the sun and planets as revolving around the Earth and interpret their motion accordingly. In contrast, someone working within the heliocentric paradigm (where the sun is central) would interpret the same celestial motions very differently, seeing the Earth as moving around the sun. Though both observers are observing the same phenomena, that is, planetary motion, their interpretations are shaped by their theoretical commitments.

- Focus on the history of science in Kuhn

The cumulative view of science holds that later theories are improved versions of earlier ones, with greater empirical content, and that such progressive growth is unmatched in any other domain. For historicists of science like Kuhn, however, scientific change is not cumulative but transformative, with later theories not necessarily superior to earlier ones. Kuhn's legacy lies in making it untenable to ignore the history of science; in the post-Kuhnian era, attention to historical development became unavoidable.

- Science is a social activity, not a rational one

Another important impact of Kuhn is the focused attention on the social context in which science takes place, which was ignored by traditional philosophy of science. Samir Okasha (2016) states: "Science for Kuhn is an intrinsically social activity: the existence of a scientific community, bound together by allegiance to a shared paradigm, is a prerequisite for the practice of normal science." Science after Kuhn is viewed as a product of the society in which it is practised. Also, the phrase 'scientific community', widely used in the post-Kuhnian era, emphasises that science is a collective, community-based enterprise rather than a purely individual activity.

- Kuhn on what scientific rationality involves

Ladyman's (2002) succinct remarks in his book *Understanding Philosophy of Science* capture the radical shift Kuhn introduced: "Hume thought that science was inductive and irrational, Popper thought it was non-inductive and rational, and Carnap thought it was inductive and rational… In contrast to the trio above, Kuhn seems to argue that science is both non-inductive and non-rational." Samir Okasha's remark may offer a helpful clarification to the impression given by Ladyman: "Kuhn was not trying to show that science was irrational, but rather to provide a better account of what scientific rationality involves" (2016).

## Summarized Overview

Thomas Kuhn's intervention in the philosophy of science marked a radical shift from traditional views of science as a steady, rational, and cumulative enterprise. Challenging both the Enlightenment model and the positivist-verificationist tradition, Kuhn argued that science operates within paradigms—shared frameworks of assumptions, methods, and standards upheld by scientific communities. Scientific progress, he claimed, does not unfold linearly through the accumulation of truths but through disruptive paradigm shifts triggered by unresolved anomalies. Each new paradigm redefines what counts as legitimate problems, methods, and solutions, rendering past and present scientific theories often incommensurable. Kuhn's model of scientific development—pre-paradigm, normal science, crisis, revolution, and new normal science—presents a cyclical and transformative structure rather than a linear one.

Kuhn's emphasis on the historical and social dimensions of science also disrupted the idea that science is an entirely objective, context-free activity. By showing how observation is theory-laden and how scientific inquiry is embedded in communities with shared commitments, Kuhn foregrounded the role of consensus, culture, and historical contingency in shaping scientific knowledge. His critiques extended to falsificationism, arguing that scientific revolutions are not about refuting theories through neutral observation (which does not exist for him as every observation is theory-laden) but about replacing entire worldviews. In short, Kuhn not only redefined scientific rationality but also laid the groundwork for a more complex explanation of science as a historically situated, socially embedded, and philosophically rich human endeavour.



## Self-Assessment

1. What does Kuhn mean by a paradigm, and how does it shape the process of normal science?
2. How does Kuhn's view of scientific progress challenge the Enlightenment and logical positivist narratives of cumulative development?
3. What is the concept of incommensurability in Kuhn's philosophy, and how does it impact the comparison between paradigms?
4. In what way does Kuhn incorporate the social and historical dimensions into his conception of science?

## Assignments

1. Critically examine Kuhn's idea of scientific revolutions. How does it differ from the falsificationist and verificationist models of scientific progress?
2. Discuss the implications of Kuhn's theory of paradigms and paradigm shifts for science education and scientific objectivity.
3. Analyze the role of the scientific community in Kuhn's account of scientific development. How does this contrast with the traditional view of science as an individual, rational pursuit?
4. "Observation is theory-laden." Discuss this statement in the light of Kuhn's rejection of the neutrality of empirical observation and its implications for scientific inquiry.

## Reference


1. Chalmers, A. (2013). *What is This Thing Called Science*? (4th ed.). Hackett Publishing.
2. Ladyman, J. (2002). *Understanding Philosophy of Science*. Routledge.
3. Okasha, S. (2016). *Philosophy of Science: A Very Short Introduction*. Oxford University Press.
4. Carnap, R. (2011). *Testability and meaning.* Literary Licensing, LLC.


## Suggested Reading


1. Kuhn, T. S. (1962). *The Structure of Scientific Revolutions* (50th Anniversary ed.). University of Chicago Press.
2. Popper, K. (1959). *The Logic of Scientific Discovery*. Hutchinson & Co.
3. Godfrey-Smith, P. (2003). *Theory and Reality: An Introduction to the Philosophy of Science.* University of Chicago Press.

## Space for Learner Engagement for Objective Questions

Learners are encouraged to develop objective questions based on the content in the paragraph as a sign of their comprehension of the content. The Learners may reflect on the recap bullets and relate their understanding with the narrative in order to frame objective questions from the given text. The University expects that 1 - 2 questions are developed for each paragraph. The space given below can be used for listing the questions.

# UNIT 2
# Paul Feyerabend: Against Method

## Learning Outcomes

By the end of this unit, the learner will be able to:

- examine Paul Feyerabend's development of epistemological and methodological anarchism in opposition to the fixed scientific method
- analyze the limitations of traditional scientific rationality as portrayed by logical positivism, Popper's falsificationism, and Kuhn's paradigm theory
- interpret Feyerabend's view of scientific progress and the role of non-scientific elements in theory development
- evaluate the political and democratic implications of Feyerabend's philosophy of science
- discuss the relevance of Feyerabend's critique in the context of cultural pluralism, scientism, and the marginalization of alternative knowledge systems



## Background

Is there a unique method for science that makes it distinct from other forms of knowledge? Different attempts have been made by scientists to respond to this question and define science in a way that clearly distinguishes it from other forms of knowledge. However, all of these attempts have encountered significant challenges. One of the earlier approaches was taken by the positivists, who held that science is special because it is derived from facts through observation and verification. However, this view could not be sustained, as the 'facts' were not as straightforward as they seemed. The facts are 'theory-laden,' shaped by the prior theories or assumptions we hold, and can thus be fallible. Moreover, no convincing explanation has been offered on how scientific theories can be logically derived from such facts.

Popper's falsificationism, proposed as an alternative, did not perform any better. While it avoided the need for verification, it still failed to account for how scientific theories can be conclusively falsified. In practice, when a prediction fails, it is often unclear whether the theory itself is at fault or if other external factors, such as auxiliary hypotheses, are to blame. This ambiguity makes falsification almost as elusive or abstract as confirmation.

Kuhn shifted the discussion by focusing on the theoretical frameworks in which science operates. He emphasised that scientists living in rival paradigms 'live in different worlds' and perceive the world in fundamentally different ways. This idea made it difficult for him to clearly explain how a change from one paradigm to another during a scientific revolution could be considered a step forward or progress. One philosopher of science who drew a radical conclusion amidst these debates was Paul Feyerabend. He was not surprised by the failures of earlier attempts and developed what he famously called an "anarchistic" theory of science, challenging the very idea that science must follow any fixed method. In other words, he argued that there is no distinct characterisation that makes science unique or superior to other forms of knowledge. For Feyerabend, the lesson from history is not that science follows paradigms; rather, it often progresses by violating established norms, mixing traditions, and embracing ideas that may initially seem irrational.

## Keywords

Epistemological anarchism, No method, Historicism, Freedom, Humanism

## Discussion

### 3.2.1. Introduction: Science Without a Method?

- Critic of scientific methodology

Paul Feyerabend (1924-94) is one of the most persistent critics of methodology in the history of the philosophy of modern science. He is also one of the three staunch critics of Popper during this period, the other two being Imre Lakatos and Thomas Kuhn. With differences in their philosophies of science, these thinkers contributed to the advancement of the philosophy of science in their responses to the theory of falsification. Feyerabend's philosophical development is directly connected to the turbulent times through which he lived, from logical positivism to post-modernism.

Feyerabend was born in Austria in 1924. His early studies in physics were interrupted by World War II, during which he served as an infantry officer in the German army. A bullet in his spine caused him physical difficulties that lasted until his death.

- Method of science is neither unique nor rational

After the war, he shifted his academic focus to the philosophy of science. He spent a year working with Karl Popper but eventually moved to California, United States, where he spent most of his life. He also spent much time interacting with and confronting Popper and Lakatos in London. He published a radical book, *Against Method: Outline of an Anarchistic Theory of Knowledge*, in 1975, in which he challenged all attempts, especially those by logical positivists, to provide an account of scientific method that attributes a special status to science. He strongly argued that there was no such method and that science does not possess features that render it necessarily superior to other forms of knowledge. The method of science, he emphasised, was neither unique nor rational.

- No unified way of doing science

Feyerabend rejected the most foundational thesis that distinguishes science from other disciplines or forms of knowledge: that science is (or ought to be) governed by immutable standards, methods, or rules. He strongly attacked what is known as the 'scientific method' and the methodological monism upheld by science—the idea that there is a single correct way to do science, such as verificationism, confirmationism, or falsificationism. He insisted that the history of science does not support any unified picture of how scientific knowledge grows. Instead, what we see is diversity, disorder, and even contradiction. By revisiting the scientific revolutions of the past, he argued that major breakthroughs in the history of science by Galileo, Newton, and Einstein occurred not by adhering to strict rules but by overcoming them. They cannot be captured by any strict scientific rationality.

## 3.2.2. Kuhn and Feyerabend: Agreements and Differences

- Influence of historical studies of science on Feyerabend
- Kuhn and Feyerabend rejected both verificationism/ confirmationism and falsificationism

Like Kuhn, Feyerabend was deeply influenced by historical studies of science. He agreed with Kuhn's view that scientific progress occurs through radical paradigm shifts that replace earlier frameworks. Following Kuhn, he also rejected the notion that science advances by merely accumulating facts to strengthen existing theories (verificationism/confirmationism) or by falsifying them through bold conjectures and repeated testing (falsificationism). Both were critics of the linear, cumulative, and rationalist view of science inherited from the Enlightenment.

Feyerabend's *Against Method* (1975) represents a more radical extension of some of the ideas introduced by Thomas Kuhn in *The Structure of Scientific Revolutions*, which was published a decade earlier in 1962. While Feyerabend was inspired by Kuhn's insights into the historical and sociological dimensions of science, social consensus, and the like, he went further. The radical divergence is that Feyerabend rejected the idea of any fixed method or rational structure in science. He challenged not only logical positivism and falsificationism but also Kuhn's idea that science moves, within the bounds of scientific communities and internal rationality, through structured phases (normal science → crisis → revolution → new normal). Feyerabend accused Kuhn of replacing the dogma of method with the dogma of paradigms.

- Feyerabend against Kuhn's dogma of structured phases - paradigms

Incommensurability, that is, the 'lack of common measure,' was adopted by both Kuhn and Feyerabend. Two successive and competing scientific theories are incommensurable with each other in the sense that there is no neutral way of comparing their merits. There are no common standards to evaluate their merits. In other words, there is no rational comparison possible between these theories. Feyerabend took a more extreme position and advanced a strong form of incommensurability.

- Rational comparison between two theories is not possible according to Feyerabend as well

Logical positivists challenged the incommensurability and argued that one can compare two theories using 'statements of purely observational language, uncontaminated by theoretical preconceptions.' However, for Feyerabend and other historicists, there are no pure, neutral observations in science, and the meaning of the observation terms of a theory is embedded within the theory. The idea of incommensurability leads to strict subjectivity in the realm of theory choice. As rational or logical ways of comparing various theories are not possible, Feyerabend (1975) observes that we are left only with "aesthetic judgments, judgments of taste, metaphysical prejudices, religious desires; in short, what remains are our subjective wishes." In this sense, the radical notion of incommensurability undermines the foundation of rationality in science.

- Subjective wishes play a role in scientific practice

The above view rejects the traditional explanation of (scientific) rationality, which ignores subjective or rhetorical elements such as judgment, emotions, intuitions, reasonableness, convenience, and so forth. Feyerabend's point is that these are essential components of scientific practice or progress. Strictly speaking, he never rejects metaphysics as meaningless. As a historicist, he argues that not only the theoretical terms but even the observational terms require a theoretical background for explanation. Feyerabend is convinced that "a good empiricist must be a critical metaphysician."

- Metaphysics is essential to scientific practice
- Both observation and theory are shaped by deeper assumptions

### 3.2.3 Epistemological and Methodological Anarchy: 'Anything Goes'

- No special epistemological or methodological status for science
- Anything goes

Feyerabend's philosophy ultimately developed into an anarchistic account of science, denying the existence of any special epistemological or methodological status, fixed rules, or universal standards, and consequently challenging the authority traditionally ascribed to science. If there is a single unchanging principle of scientific method, according to Feyerabend, it is the principle of "anything goes." He upheld the idea of science without rules. Many scholars in the philosophy of science affirm that there are passages in Feyerabend's writings, both early and late, that can be strictly called an extreme anarchistic account of science.

- Revolutionary changes in science happened not by sticking to strict methods and rules but by overcoming them

Chalmers (2013) observes: "Feyerabend's main line of argument attempts to undermine the characterisations of method and progress in science offered by philosophers by challenging them on their own grounds." That is, he examines episodes of scientific change from the history of science—cases widely regarded, even by his opponents, as classic examples of scientific progress—and argues that these episodes did not occur by adhering to fixed rules or methodological principles proposed by philosophers of science. These revolutionary changes would not have happened if the proponents of these changes had followed the need for coherence with previous theories and facts that traditional rationality requires.

- Most methodological rules are based on metaphysics, not pure logic
- Epistemological and methodological anarchy

Epistemological anarchism suggests that science has no special place in terms of knowledge production and perspective, and that traditional rationality is incoherent with scientific progress as commonly understood. Methodological anarchy suggests the possibility and even the need to use counter-induction in science: to propose and continuously refine theories that contradict known theories, observations, and facts. Feyerabend advocates for anarchy and liberality of perspectives by arguing that any methodology in science becomes too restrictive, and that scientific progress is made by breaking the rules instead of following them blindly.

- Feyerabend's focus is on the scientific 'practice' in history, not on the method written in classics

In short, Feyerabend's emphasis is on the scientific 'practice' in contrast to a concentration on scientific 'method,' and he has greatly contributed to modern philosophy of science in this regard. In other words, his book emphasises the 'knowledge practice' or 'research activities' of the scientific community rather than theoretical or rational knowledge. This new turn attempts to show the deficiencies of widespread ideas about the nature of scientific knowledge. According to him, the only feasible way to explain scientific success or progress is through a historical explanation, which is anarchic; thus, anarchism must replace rationalism in the theory of knowledge.

### 3.2.4 Freedom and Humanism in Feyerabend

- Call for democratization of scientific knowledge

Feyerabend builds on the radical implications of his critiques in *Against Method* and pushes further toward a deeply democratic, pluralistic, and anti-authoritarian view of science in his later work, *Science in a Free Society* (1978). He rejects the notion of the 'scientific expert' and argues that the governance of scientific knowledge and its applications, especially in matters affecting public life, should not remain the exclusive domain of experts. All citizens should have a participatory role in shaping scientific policy and practice. He challenges the privileged status of science, asserting that it is only one form of enquiry among many legitimate ways of knowing the world. The portrayal of science as universally objective functions as a vehicle for cultural imperialism, suppressing indigenous knowledge systems, art, and religion, and marginalising non-Western worldviews.

- Science dominates not by merit but because other knowledge systems have been systematically excluded

Feyerabend affirms that his aim is not to dismiss the relevance or achievements of science, but rather to reject the way in which science 'reigns supreme.' He does not dismiss the point that science has made tremendous contributions to our understanding of the world, leading to many practical achievements. In his critique of the special status of science, he emphasises that the 'results' of science do not prove its excellence, as these results have depended on the presence of non-scientific (metaphysical) elements. He asserts that "today science prevails not because of its comparative merits, but because the show has been rigged in its favour," (1978) and that other traditions of knowledge have not been given a chance. In this regard, he is known as the liberator of humanity from science. He states, "the truth is that: Science is much closer to myth than a scientific philosophy is prepared to admit. It is one of the many forms of thought that have been developed by man, and not necessarily the best. It is conspicuous, noisy, and impudent, but it is inherently superior only for those who have already decided in favour of a certain ideology, or who have accepted it without ever having examined its advantages and its limits" (1975).

He warns humanity not to be carried away by scientism, the tendency to absolutise or glorify science as a sacred discourse. Both ignoring and sacralising science is irrational. The celebration of the one-sided growth or progress of science has caused significant harm to humanity and the environment, and humanity needs to be liberated from the overarching clutches of science. Chalmers explains Feyerabend's stance: "according to Feyerabend, the high regard for science is a dangerous dogma, playing a repressive role similar to that which he portrays Christianity as having played in the seventeenth century, having in mind such things as Galileo's struggles with the Church."

- High regard for science is a dangerous dogma

The true power of Feyerabend's critique of scientific method and supremacy lies in his comparison between science and political liberalism. Just as a liberal society thrives on freedom of thought, diversity of beliefs, and open debate, Feyerabend insists that science must also embrace pluralism of methods, theories, and worldviews. His much-discussed stance of epistemological and methodological anarchism is not a call for chaos but a deeper affirmation of scientific pluralism, grounded in his broader commitment to political pluralism and democratic socialism. The only principle, he provocatively claims, that does not hinder scientific progress is: "anything goes." To safeguard human freedom and creativity, he argues that the separation of church and state must be complemented by a separation of science and state. Just as religious institutions no longer dominate public life, science, too, should not hold exclusive authority over truth and policy. Only such a decentered, pluralistic framework can help humanity realise its full potential. For Feyerabend, the dominance of science poses a real threat to democracy, and the true ideal of a free society is one in which all traditions—scientific or otherwise—enjoy equal rights and equal access to the centres of power.

- True scientific progress and a free society require pluralism, equality among traditions, and the separation of science from state authority



## Summarized Overview

Paul Feyerabend presents one of the most radical and influential critiques of the dominant philosophies of science in the 20th century. Rejecting the idea that science is a unified, rational, and methodologically consistent enterprise, Feyerabend argues that current philosophies of science are hopelessly disconnected from actual scientific practice, and if taken seriously, they would stifle the very creativity and diversity that drive scientific progress. According to him, science is not a single rational structure, but a collage of competing theories, methods, practices, and worldviews, many of which have historically borrowed from non-scientific or even irrational sources. This view culminates in his famous assertion: "Science is not one thing, it is many." Instead of viewing science as a product of pure reason or objective method, he emphasises its social, historical, and pluralistic character.

Feyerabend's challenge extends beyond academic theory to the political role of science in modern society. In works like *Science in a Free Society*, he argues that the unchecked authority of science poses a danger to democracy, as it tends to silence alternative perspectives and monopolise truth. He advocates for the democratic supervision of science by laypeople, highlighting how expert opinions are often biased, institutionally conditioned, and ideologically motivated. His call for epistemological anarchism—summed up in the slogan "anything goes"—is rooted in his deeper commitment to epistemic and political pluralism. Drawing a bold parallel with the separation of church and state, Feyerabend proposes a similar separation of science and state, allowing all traditions of knowledge equal access to power and public life. This, he argues, is essential for creating a genuinely free, democratic, and humane society.

## Self-Assessment

1. Why does Feyerabend reject the idea of a unified scientific method?
2. What is the principle of "anything goes," and how does it reflect Feyerabend's view of science?
3. How does Feyerabend's critique of Kuhn differ from his critique of Popper?
4. What role does incommensurability play in Feyerabend's epistemological anarchism?
5. In what way does Feyerabend compare science to religion or ideology?



## Assignments

1. Critically examine Feyerabend's argument that "science is not one thing, it is many." How does this claim challenge traditional notions of scientific rationality and progress?
2. Discuss the concept of epistemological and methodological anarchism in Feyerabend's thought. Is his "anything goes" a call for intellectual freedom or epistemic relativism?
3. Analyse Feyerabend's critique of the special status of science in modern society. How does his view of the relationship between science, democracy, and pluralism reflect his political philosophy?

4. Compare Feyerabend's account of incommensurability with that of Thomas Kuhn. How do their views on paradigm shifts differ in terms of rationality and theory choice?
5. To what extent can Feyerabend's ideas be applied to current debates around indigenous knowledge systems, scientific authority, and epistemic justice? Provide examples to support your argument.

## Reference


1. Chalmers, A. (1999). *What is This Thing Called Science?* (3rd ed.). Open University Press.
2. Feyerabend, P. (1975). *Against Method: Outline of An Anarchistic Theory of Knowledge*. New Left Books.
3. Feyerabend, P. (1978). *Science in a Free Society*. New Left Books.
4. Kuhn, T. S. (1962). *The Structure of Scientific Revolutions*. University of Chicago Press.
5. Lakatos, I., & Musgrave, A. (Eds.). (1970). *Criticism and the Growth of Knowledge*. Cambridge University Press.


## Suggested Reading


1. Preston, J. (1997). *Feyerabend: Philosophy, science and society*. Polity Press.
2. Oberheim, E. (2006). Feyerabend's philosophy. De Gruyter.
3. Lakatos, I. (1978). *The Methodology of Scientific Research Programmes: Philosophical Papers*, Volume 1. Cambridge University Press.
4. Longino, H. E. (1990). *Science as social knowledge: Values and objectivity in scientific inquiry.* Princeton University Press.
5. Harding, S. (1991). *Whose science? Whose knowledge? Thinking from women's lives.* Cornell University Press.

## Space for Learner Engagement for Objective Questions

Learners are encouraged to develop objective questions based on the content in the paragraph as a sign of their comprehension of the content. The Learners may reflect on the recap bullets and relate their understanding with the narrative in order to frame objective questions from the given text. The University expects that 1 - 2 questions are developed for each paragraph. The space given below can be used for listing the questions.

# UNIT 3
# Debates in Philosophy of Science

## Learning Outcomes

By the end of this unit, the learner will be able to:

- evaluate various philosophical attempts to distinguish science from non-science, including the perspectives of logical positivism, Popper, Kuhn, and Feyerabend
- analyse the nature and limits of scientific reasoning, particularly the challenges posed by Hume's problem of induction
- compare objectivist and constructivist views on scientific knowledge
- identify the contributions of feminist epistemology to the philosophy of science

## Background

The philosophy of science is not merely a reflection on the accomplishments of science but a sustained interrogation of its foundations, methods, limits, and claims to truth. As science has become one of the most powerful and authoritative forms of knowledge in the modern world, philosophers have sought to ask: What makes science distinctive? Can scientific knowledge be truly objective? How do scientific theories evolve, and to what extent are they shaped by social, historical, or political forces? How is scientific knowledge gendered? These are not idle questions. They sit at the heart of enduring philosophical disputes about the nature of rationality, the credibility of knowledge claims, and the very meaning of truth and reality in scientific inquiry. What emerges is not a singular image of science, but a contested and evolving field marked by methodological tensions, epistemological divides, and ideological critiques.

From the demarcation problem and the critique of induction to the rise of historicist and feminist epistemologies, the field reveals a vibrant landscape where science is examined not only as a logical system but also as a historically situated and socially embedded practice. Far from being merely technical, these debates touch upon profound philosophical issues: Is scientific progress cumulative or revolutionary? Are scientific facts discovered or constructed? Can science claim neutrality, or is it inevitably value-laden? The questions critically engage with the complexity of scientific knowledge and the philosophical frameworks through which it is understood, challenged, and reformulated.

## Keywords

Demarcation, Verification, Falsification, Induction, Feminism

## Discussion

### 3.3.1 Demarcation Problem

- What distinguishes science from non-science?

The demarcation problem is the challenge of distinguishing science from non-science, including pseudoscience, metaphysics, and other forms of knowledge. This problem remains one of the most enduring and debated questions in the philosophy of science. What is the fundamental feature of science or scientific theory that distinguishes science from non-science? Is there a single strict criterion for science?

- Different responses to the demarcation problem

Addressing this problem, philosophers from logical positivists to Popper, Kuhn, Lakatos, and Feyerabend have offered different perspectives, with some defending the objectivity and uniqueness of science, while others focus on the historical development of science (focusing on how science has been historically practised, rather than methodologies) and thus call for a more pluralistic and historical approach. Empirical testing, falsifiability, systematic methodology, and methodological anarchism (no method at all) are some features upheld by various schools of philosophy of science.



#### 3.3.1.1 Verificationism versus Falsificationism

- Scientific theories are those which can be verified or confirmed through experience

The Logical Positivists, particularly those associated with the Vienna Circle in the early 20th century, proposed verificationism as a criterion of demarcation. According to them, for a statement to be meaningful, it must either be analytically true, as in logic or mathematics (for example, 1 + 1 = 2), or empirically verifiable through observation (like 'it is raining now'). From this perspective, scientific theories are meaningful because they can, in principle, be verified or confirmed through experience. By contrast, metaphysical claims, such as 'God exists' and 'there is a soul,' are considered meaningless since they are not open to empirical testing or verification.

Karl Popper (1902–1994) raised one of the notable criticisms against verificationism, arguing that no number of observations can conclusively verify a universal scientific statement like “All metals expand when heated.” This criticism aligns with the problem of induction, or the problem of inductive reasoning, raised by the Scottish philosopher David Hume (1711–1776). Hume argued that inferring general laws from specific observations is not logically justifiable. For example, just because the sun has risen every day so far does not guarantee it will rise tomorrow. According to Hume, this undermines the logical basis of all scientific generalisations. No matter how many confirming instances we find, there is always the possibility of a future counterexample. Thus, verification was seen as too weak a criterion to separate science from non-science.

- Problem with verification

Thus, Popper proposed falsifiability: a theory is scientific only if it is falsifiable. A theory is scientific only if it makes predictions that could, in principle, be proven false by observation or experiment. The demarcation of science lies in the falsifiability of a theory. It must be noted that to call a theory falsifiable is not to say that it is false. Rather, it means that the theory makes certain predictions that are capable of being tested against experience and that can be proven false. A falsifiable theory is something that “is not compatible with every possible course of experience,” as Chalmers says. In another sense, theories such as Freudian psychoanalysis and Marxist historical materialism, which explain everything and can accommodate any outcome, are not scientific, as they are not testable and falsifiable.

- Falsifiability as the demarcation of science

### 3.3.1.2 Kuhn and Feyerabend on Demarcation

While earlier philosophers like Popper sought strict criteria to distinguish science from non-science, later thinkers like Thomas Kuhn and Paul Feyerabend challenged this very attempt. Kuhn argued that science is not a purely rational enterprise governed by universal rules but a historically evolving practice shaped by shifting paradigms. Science operates within paradigms, and the transition between paradigms is not strictly rational or objective but influenced by social, psychological, and historical factors. This makes it difficult to define a permanent boundary between science and non-science.

- Kuhn and Feyerabend challenged the idea of demarcation

Feyerabend goes further, rejecting the idea of any demarcation altogether. In his view, the history of science shows that great advances were made precisely by violating rules and mixing rationality with myth, ideology, and tradition. For him, there is no unique method of science and no feature that makes science inherently superior. Thus, he called for

- Feyerabend’s epistemological anarchism rejects the demarcation epistemological anarchism and pluralism, suggesting that the quest for a strict demarcation is misguided and oppressive. Both thinkers, though from different directions, undermine the demarcation project, and the demarcation problem itself is a misguided quest for Feyerabend.

### 3.3.2 How Do We Justify Scientific Reasoning?

- Logicians and mathematicians rely on deductive reasoning

What exactly is the nature of scientific reasoning, and how much confidence can we place in the inferences scientists make? This has been a critical debate in the history of science. As is well known, logicians and mathematicians depend on deductive patterns of reasoning, while scientists largely depend on inductive patterns of reasoning. Deductive reasoning, or deductive inference, has the following pattern:

All two-legged animals are human beings.

X is a two-legged animal.

Therefore, X is a human being.

- The premises entail the conclusion in deductive inference

In the above example, the first two statements are called the premises of the inference, while the third statement is called the conclusion. This is a deductive inference with the following property: if the premises are true, then the conclusion must also be true. If the premises are true, they draw a logical conclusion. That is, if both premises, "All two-legged animals are human beings" and "X is a two-legged animal," are true, then it necessarily follows (logically follows) that "X is a human being." Here, the premises of the inference entail the conclusion, even if it is clear to us that the premises of the inference here are certainly not true; there are many two-legged animals that are not human (like ostriches and emus). The inference is deductive due to an appropriate relation between premises and conclusion; that is, if the premises are true, the conclusion must also be true. Whether the premises are actually true is a different matter, which doesn't affect the status of the inference as deductive.

The certainty in deductive reasoning—necessarily arriving at a true conclusion from true premises—does not hold for inductive reasoning. Despite this defect, we most often rely on inductive reasoning in our lives; we draw a general conclusion from many particular instances. For example, when we switch on our mobile in the morning, we are confident that it will not explode. That is because we have turned on our mobile every morning, and it has not exploded up to now. Here, the

- We engage in inductive reasoning in daily life

inference that 'up until now my mobile has not exploded when I switched it on' to 'my mobile will not explode when I switch it on this time/tomorrow' is inductive reasoning. The premises here do not entail the conclusion as was the case in deductive inference. That means it is possible that the mobile explodes this time while switching it on. However, we naturally justify our conviction in inductive reasoning, take it as an unavoidable part of our lives, and engage in day-to-day activities.

- Moving from limited data to a more general conclusion

Scientists use this very inductive reasoning whenever they move from limited data—such as all pieces of metal examined/experimented conducting electricity—to a more general conclusion: all pieces of metal conduct electricity. Popper acknowledges the problem underlying this and affirms that no number of instances can verify a theory and make a universal law out of it. We cannot prove that a theory is true from a limited data sample. That is, we cannot conclusively and universally verify any theory. All we can do is falsify it by presenting a single counterexample and refuting the existing theory.

- Restricting scientists to the use of deductive reasoning fails

For example, a scientist cannot verify a theory that "all metals conduct electricity." But if a scientist finds one piece of metal that does not conduct electricity, this can prove that the theory is false. The inference from "this piece of metal does not conduct electricity" to "it is false that all pieces of metal conduct electricity" is deductive reasoning—the premise entails the conclusion. However, Popper's attempt to show that a scientist can do science without inductive reasoning could not succeed for obvious reasons. A scientist collects experimental data not only to prove that certain theories, including those of their rivals, are false, but also to convince people that their own theory is true. This makes it difficult for a scientist to forgo inductive reasoning.

- Inductive reasoning is logically/rationally justified. It is justified on the assumption of uniformity of nature

Then, the question is, what justifies our faith in induction? Hume challenged the idea that the use of induction can be rationally justified. Hume's point is that we use induction in daily life and science as a matter of brute animal habit. That is, Hume says, whenever we make inductive reasoning, we presuppose a 'uniformity of nature.' For example, when we move from "all bodies observed/examined so far obey Newton's law of gravity" to "all bodies obey Newton's law of gravity," our reasoning depends on the assumption that bodies or objects we have not examined will be similar to the bodies or objects we have examined. But how do we know that this 'uniformity of nature' assumption is true? Can we prove its truth? No, Hume says, because we can imagine a universe without uniformity of nature—a universe where mobiles might explode for no reason and the sun might rise in the west. Since a non-uniform universe is conceivable, we cannot strictly prove the truth of uniformity of nature. Now, as we cannot prove the uniformity of nature, we might again find a reason for its truth. Uniformity of nature has always held true up to now, and that gives us sufficient reason to think that it is true. But again, the problem arises. That itself is an inductive argument.

## 3.3.3 Scientific Knowledge: Objectivism vs. Constructivism

- Science aims to discover truths about the natural world which exist independently of human perceptions

The failure of demarcation leads to deeper debates about the nature of scientific knowledge. There are mainly two epistemic visions in science: scientific objectivism and constructivism. Scientific objectivism is founded on the idea that science aims to discover truths about the natural world that exist independently of human perception, belief, or culture. This position holds that observation and experimentation can, over time, yield reliable knowledge about the world and that scientific claims are justified through empirical evidence and logical reasoning.

- Objectivism and universality of scientific knowledge

Objectivist philosophers often emphasise the universality of scientific knowledge and the possibility of separating the observer from the observed. The objectivist ideal is central to logical positivists and later to critical rationalists like Karl Popper, who argued that science progresses by eliminating false hypotheses through falsification. The emphasis is on the clarity, precision, and value-neutrality of science.

- There are no pure facts. Facts themselves are infected by our presuppositions and theories.

Constructivists, in contrast, affirm the role of human agency in scientific knowledge. They argue that scientific knowledge is not simply discovered by scientists but constructed. This does not mean it is invented arbitrarily, but rather that it is shaped by the assumptions, categories, tools, and social contexts of scientists. What counts as a scientific fact is often the product of negotiation, interpretation, and historical circumstance. Scientific theories do not emerge in a vacuum but are influenced by pre-theoretical assumptions, cultural norms, institutional structures, and the language in which problems are framed. They demonstrate that science has both subjective and objective elements. Samir Okasha (2016) argues that the theory-ladenness of data forces us to abandon the concept of objective truth: "for to be objectively true, our theories or beliefs must correspond to the facts, but the idea of

- Historicism focuses on actual historical developments and sociological factors of science

- Historicists challenge logical positivism on various grounds

- Sex/gender matters to the production of scientific knowledge and scientific practice

such a correspondence makes little sense if the facts themselves are infected by our theories. This is why Kuhn was led to the radical view that truth itself is relative to a paradigm."

Ladyman (2002) observes about historicism in science: "But historicists, like Hanson, Feyerabend, Kuhn, Lakatos etc., tried to demythologise the logical positivists' view of science and to arrive at a picture that is more faithful to the actual historical developments and sociological factors of science." Chalmers (2013) explains how there is a radical change not only in scientific theories but also in observational facts in Kuhn's philosophy of science: "It would seem that the scientific revolution involved not just a progressive transformation of scientific theory, but also a transformation in what were considered to be the observable facts!"

In short, historicists challenge logical positivism primarily on the following points: a) Rationality of science - Historicism argues that science is non-rational as there can be, and have been, many methods in science. Strictly put, there is no single method in science, but many practices across the history of science; b) Cumulative growth - Historicism argues that growth is transformative, not progressive, and later theories are not necessarily better than the previous ones; c) Objectivity in science - Historicism shows that science has both subjective and objective elements; d) Monopoly of truth - Historicism challenges this idea by stating that monopoly exists because "the show has been rigged" and that other resources are also reliable; e) Superiority of scientific theories to any other belief system as science is immutable - Historicism affirms that there is nothing special about the scientific enterprise and that scientific theories do change; f) Dichotomy between the context of discovery and the context of justification - Historicism denies any such dichotomy; g) Clear distinction between observational terms and theoretical terms - However, historicism denies this distinction as there is no 'pure' observation and all observations are theory-laden.

## 3.3.4 Feminist Epistemology and Philosophy of Science

Feminist epistemology and philosophy of science examine the various ways in which gender influences our understanding of knowledge, knowers, and inquiry. Put differently, feminist perspectives on science are founded on the premise that sex/gender matters to the production of scientific knowledge and practice. The feminist approaches and perspectives expose how dominant epistemic conceptions and practices of knowledge attribution, acquisition, and justification often marginalise women and subordinated groups, and how they can be reformed to serve the interests of those excluded.

- Science is gendered

Major thinkers in feminist philosophy of science include Sandra Harding, Evelyn Fox Keller, and Donna Haraway. They emphasise situated knowledge, gendered perspectives in science, and critiques of traditional notions of objectivity.

- Different ways in which conventional models of scientific knowledge disadvantage women

Feminist scholars argue that conventional models of knowledge and knowledge practices disadvantage women in different ways such as: 1) excluding them from inquiry; 2) denying them epistemic authority; 3) undermining "feminine" cognitive styles; 4) producing theories that represent women as inferior or define them only in terms of service to male interests; 5) rendering women's activities, interests, and gendered power relations invisible in social theories; 6) producing certain knowledge that is not useful for subordinate sections or that reinforces gender and other social hierarchies.

- Knowledge is situated

The central concept in this tradition is situated knowledge - the view that knowledge is always shaped by the social and historical position of the knower, and the criticisms are grounded in a critique of prevailing conceptions of objectivity, knowers, and methodology in science. Feminist epistemologists have also shown how the entry of women and feminist scholars into disciplines has generated new questions, methods, and insights. They argue that gendered and feminist perspectives have played a causal role in transforming the sciences and defend these changes as epistemic progress.



## Summarized Overview

The distinction between science and non-science remains philosophically contested, with thinkers offering diverse criteria such as verification, falsifiability, and methodological openness. While logical positivists emphasise empirical verification, Popper critiques this with his principle of falsifiability, arguing that scientific theories must be open to refutation. However, Kuhn's paradigm theory and Feyerabend's methodological anarchism question the very idea of fixed scientific methods, highlighting the historical, psychological, and sociopolitical dimensions of scientific change. Inductive reasoning, though central to scientific practice, is shown to lack a rational foundation, as Hume's problem of induction reveals its dependence on the unprovable assumption of nature's uniformity. Objectivist views of science posit a value-free, observer-independent knowledge, whereas constructivist and feminist perspectives expose how scientific knowledge is situated and shaped by human interests, social location, and power structures. These debates collectively challenge any simplistic or singular explanation of science, pointing instead to its plural, situated, and evolving character.

## Self-Assessment

1. What is the demarcation problem in the philosophy of science? Why is it considered unresolved?
2. How does Karl Popper's concept of falsifiability differ from the logical positivist principle of verification?
3. What is the problem of induction as posed by David Hume, and how does it affect scientific reasoning?
4. What do philosophers mean by 'theory-ladenness of observation'? Give an example.
5. Briefly explain the difference between scientific objectivism and constructivism.

## Assignments

1. Critically evaluate the various philosophical responses to the demarcation problem, with special reference to Popper, Kuhn, and Feyerabend.
2. Discuss the limitations of inductive reasoning in scientific practice. How have philosophers like Hume and Popper addressed the justification of induction?
3. Examine how feminist epistemologists have contributed to our understanding of scientific knowledge. How do concepts like situated knowledge challenge traditional views of objectivity?
4. Compare and contrast the views of Thomas Kuhn and Paul Feyerabend on the development of scientific knowledge. What implications do their views have for scientific rationality?
5. "Scientific knowledge is both constructed and constrained." Discuss this statement with reference to debates between scientific realism and anti-realism.



## Reference

1. Hume, D. (1999). *An Enquiry Concerning Human Understanding*. Oxford University Press.
2. Chalmers, A. (2013). *What Is This Thing Called Science?* (4th ed.). Open University Press.
3. Popper, K. R. (2002). *The Logic of Scientific Discovery* (Original work published 1934). Routledge.

4. Kuhn, T. S. (1996). *The Structure of Scientific Revolutions* (3rd ed.). University of Chicago Press.
5. Feyerabend, P. (1993). *Against Method* (3rd ed.). Verso.
6. Hanson, N. R. (1958). *Patterns of Discovery*. Cambridge University Press.
7. Churchland, P. M. (1979). *Scientific Realism and the Plasticity of Mind*. Cambridge University Press.
8. Harding, S. (1991). *Whose Science? Whose Knowledge? Thinking from Women's Lives*. Cornell University Press.
9. Hacking, I. (1983). *Representing and Intervening*. Cambridge University Press.
10. Godfrey-Smith, P. (2003). *Theory and Reality: An Introduction to the Philosophy of Science*. University of Chicago Press.
11. Okasha, S. (2016). *Philosophy of Science: A Very Short Introduction* (2nd ed.). Oxford University Press.

## Suggested Reading

1. Lipton, P. (2004). *Inference to the Best Explanation* (2nd ed.). Routledge.
2. van Fraassen, B. C. (1980). *The Scientific Image*. Oxford University Press.
3. Reichenbach, H. (1938). *Experience and Prediction*. University of Chicago Press.
4. Goodman, N. (1983). *Fact, Fiction, and Forecast* (4th ed.). Harvard University Press.
5. Keller, E. F. (1985). *Reflections on Gender and Science*. Yale University Press.
6. Longino, H. E. (1990). *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry*. Princeton University Press.
7. Couvalis, G. (1997). *The Philosophy of Science: Science and Objectivity*. Sage Publications.
8. Latour, B., & Woolgar, S. (1986). *Laboratory Life: The Construction of Scientific Facts* (2nd ed.). Princeton University Press.

## Space for Learner Engagement for Objective Questions

Learners are encouraged to develop objective questions based on the content in the paragraph as a sign of their comprehension of the content. The Learners may reflect on the recap bullets and relate their understanding with the narrative in order to frame objective questions from the given text. The University expects that 1 - 2 questions are developed for each paragraph. The space given below can be used for listing the questions.

# BLOCK 4
# Philosophy of Technology

# UNIT 1
# Introduction to Philosophy of Technology

## Learning Outcomes

By the end of this unit, the learner will be able to:

- identify and explain the historical-philosophical origins of the concept of technology, particularly the Greek distinction between techne and episteme
- examine the debate between instrumentalist and substantivist views of technology based on their assumptions about nature of technology
- analyze the role of technology in shaping the modern world
- evaluate the idea of technological determinism

## Background

The philosophical engagement with technology traces its roots back to ancient Greece, where thinkers like Plato and Aristotle explored fundamental questions about the nature of making and human interaction with the material world. The Greek term *techne*, from which 'technology' is derived, originally referred to craft knowledge or skilled production, encompassing various domains such as carpentry, music, medicine, and governance. Aristotle's metaphysical distinction between *physis* (natural entities) and *poiesis* (human-made artifacts) laid the groundwork for later philosophical reflections on technology. Though not identified as a distinct field then, these classical inquiries formed the embryonic foundation of what is now called the philosophy of technology.

As a distinct area of philosophical inquiry, the philosophy of technology began to emerge more explicitly in the 19th century, particularly with Ernst Kapp, who proposed that tools are projections of human organs. The advent of industrialisation and the rapid growth of techno-scientific systems in the 19th and 20th centuries catalysed a shift in how technology was understood, moving from localized, human-centred craftsmanship to vast automated systems shaping society at every level. Modern thinkers like Martin Heidegger and Andrew Feenberg went further to question not only what technology does but what it means. Feenberg, emphasising the centrality of labour and the transformation of human existence, wrote: "Philosophy begins by interpreting the world in terms of the fundamental fact that humanity is a laboring sort of animal constantly at work transforming nature." This critical turn in the philosophy of technology invites deeper reflection on the cultural, ethical, and existential implications of technological development.

## Keywords

Techne, Episteme, Poiesis and Physis, Instrumentalism, Substantivism, Technological determinism

## Discussion

### 4.1.1 Origin and Meaning of Technology: Greek Antiquity

The history of thinking about technology is as old as thinking humans, and the philosophy of technology is a reflection on what technology is. Philosophy of technology, as a systematic field, is comparatively new. It makes philosophical investigation akin to many other domain-specific subfields of philosophy, such as the philosophy of physics or the philosophy of biology. Its emergence as a notable philosophical specialization is often traced to Ernst Kapp's *Foundations of a Philosophy of Engineering* (1877). As a field in the making, the philosophy of technology is considered a collection of different approaches to or styles of doing philosophy, denoting a wide variety of philosophical endeavours that critically evaluate technology in one way or another.

- Philosophy of technology is a reflection on what technology is

Plato and Aristotle addressed questions related to the making of things. The term 'technology' (and 'technique') is derived from the ancient Greek notion of 'techne', meaning 'art' or 'craft-knowledge', and 'logos', which means study. 'Techne' suggests the body of knowledge associated with a particular practice of making. Scholars believe that originally the term referred to a carpenter's craft knowledge, that is, how to make objects from wood, and later it was extended to include all sorts of craftsmanship, such as the ship captain's techne of piloting a ship, the musician's techne of playing a particular kind of instrument, the farmer's techne of working

- Techne meant art or craft knowledge in ancient Greek the land, the statesman's techne of governing a state or *polis*, or the physician's techne of healing patients (Nye, 2006; Parry, 2008). This view is held by Nye and Parry in their respective works.

- Fundamental distinction between natural and human-made objects

In his work *Physics* (Book II, Chapter 1), Aristotle makes a fundamental metaphysical distinction between natural and human-made objects, addressing the states of affairs in the natural world and human actions. He affirms a fundamental metaphysical difference between these two domains of objects based on the way in which natural things and human-made objects come into being. The fundamental distinction lies in the kinds of principles of existence that underlie the entities that exist in the two domains – *physis* and *poiesis*.

- Fundamental distinction between natural and human-made objects

According to Aristotle, things in the natural realm (*physis*) have certain principles within themselves by which they come into being, exist, and move (movement includes movement in space or change). *Physis* can be simply translated as nature. Nature is that which creates itself, that which emerges from out of itself. For instance, a plant comes into being and remains in existence by means of growth, metabolism, and photosynthesis. These are the processes that operate by themselves without the interference of an external agent. In contrast, things in the non-natural realm (*poiesis*) have principles of existence and movement that are external to them and can be attributed to an external agent. *Poiesis* is the practical activity of making in which human beings engage when they produce something, that is, artifacts. It includes the products of art, craft, and social convention. For example, a wooden bed does not exist or move on its own. Rather, it exists as a consequence of a carpenter's action of making it and an owner's action of maintaining it.

- Episteme relates to nature, while techne and phronesis guide craft and practical life

Both Plato and Aristotle make a distinction between *episteme* and *techne* as two forms of knowledge pertaining to different domains of the world. This forms a foundational distinction in Western philosophy of technology as well. In the *Nicomachean Ethics* (Book VI), Aristotle classifies five modes of knowledge (virtues of thought) that humans are capable of: science or scientific knowledge (*episteme*), art or craft knowledge (*techne*), prudence or practical wisdom (*phronesis*), intellect or intuitive apprehension (*nous*), and philosophical wisdom (*sophia*). While *episteme* applies to the natural domain, *techne* and *phronesis* apply to the non-natural domain. The latter two are subdivided based on the point that while *phronesis* applies to actions in general life, *techne* applies to crafts.

- Episteme is theoretical knowledge, while techne is practical, skill-based knowledge

Put differently, *episteme* refers to universal knowledge, the kind that is pursued in science, which is grounded in logic and principles. In contrast, *techne* is concerned with the production or making of things and is guided by an end external to the activity itself. *Techne* includes a rational ability to make something grounded in experience and underlies activities such as architecture, medicine, and craftsmanship. It reflects human engagement with the material world through skilful intervention. That is, *episteme* is theoretical knowledge and *techne* is practical knowledge. The contemporary distinction between 'pure science' and 'applied science' is fundamentally based on the distinction between *episteme* and *techne*. Given the rigorous philosophical thinking on the making of things in ancient Greece, some scholars view the philosophy of technology as not a recent area of study; rather, it has its beginnings with the Greeks and is, in fact, the foundation of all Western philosophy.

## 4.1.2 Transformation of Techne into Modern Technology

- Technology evolved from skilled craft (techne) to mechanised, science-driven systems

While the classical notion of *techne* emphasised craft or skilled practice, the modern conception of technology has undergone a significant transformation, marked by a visible shift from *techne* to mechanised and instrumental forms. During the Renaissance and Enlightenment periods, technological development became increasingly aligned with the progress of science. With the Industrial Revolution and the rise of a techno-scientific worldview, technology emerged as one of the most defining phenomena of modern society. With the Industrial Revolution, technology came to be understood not merely as a set of tools or techniques but as a powerful system shaping labour, production, and social life on a massive scale.

- Modern technology is systematised and automated, unlike pre-modern techne

Modern technology differs from pre-modern techne in both scale and structure. It is increasingly characterised by automation, standardisation, and efficiency. Technology is no longer restricted to isolated crafts or techniques but has evolved into complex systems such as digital networks, infrastructures, and algorithmic processes that are deeply embedded in modern social life. This transformation also marks a shift from making as a human-centred act to machinic/mechanic production, where technologies operate independently of individual skill.

While philosophers have reflected on technology-related matters and the questions of making since antiquity, philosophical reflections on technology before the 19th century were not

- Pre-19th-century philosophy did not consider technology as an independent field

- Technology and science became prominent phenomena only by the late 19th and early 20th centuries

- Heidegger examines the essence of technology beyond its functional aspects

- Early philosophy of technology focused on the existential meaning of Technik

- Technology's role, influence, and hidden costs in determining and shaping human life

aimed at explaining technology as such. Rather, their aim was to examine technology in the context of larger and general philosophical concerns, leading to clarification of traditional philosophical issues other than technology. Furthermore, no philosopher before the 19th century considered him/herself a philosopher or expert in the philosophy of technology.

One obvious reason for this is that technology had not yet become the enormously powerful and manifestly binding phenomenon it became before the mid to late 19th century. The same holds true for science. It was only by the end of the 19th century that natural science, in its modern form, emerged from natural philosophy, and technology began to manifest as a phenomenon distinct from science. Don Ihde states: "until the twentieth century the phenomenon of technology remained a background phenomenon," and the philosophy of technology "is primarily a twentieth-century development."

Heidegger (1977), in his seminal essay *The Question Concerning Technology*, argues that the 20th century witnessed not only an unprecedented acceleration in technological development, making technology an increasingly visible and inescapable part of everyday life, but also a fundamental transformation in the very nature of technology itself. While Heidegger uses the term Technik, his inquiry is ultimately directed at uncovering the deeper essence or being (nature) of technology, beyond its functional or instrumental aspects.

It is important to note the linguistic distinction in German between Technik and Technologie: the former refers more broadly to mechanical crafts and engineering practices, whereas the latter typically signifies modern, high-tech technologies such as biotechnology or nanotechnology. The academic field of philosophy of technology, particularly in its early European formation, arose through critical reflection on Technik as a historical and existential phenomenon rather than on technology as specialised innovation. Heidegger's intervention thus marks a pivotal moment in shifting the philosophical focus from technological tools to the ontological and cultural implications of technology as a mode of revealing the world.

These radical developments have raised fundamental philosophical questions: Is technology merely a tool that we use, or does it shape us and our world in ways we do not always control? Is technological progress always beneficial, or does it come with hidden costs? Feenberg (1999) states : "technology is still the model of being in this modern conception. This was particularly clear in the 18th-century Enlightenment, when philosophers and scientists challenged the medieval successors to Greek science with the new mechanistic worldview of Galileo and Newton. These thinkers explored the machinery of being. They identified the workings of the universe with a clockwork mechanism."

### 4.1.3 What is Philosophy of Technology, and Why Does It Matter?

- Is technology just a collection of machines, tools, and devices? Is it a set of methods or processes? Or is it something more?

One of the core challenges in the philosophy of technology is explaining what we truly mean by technology. Is it just a collection of machines, tools, and devices? Is it a set of methods or processes? Or is it something more—a system of practices shaped by culture, values, and power? Different philosophical traditions have approached this question from various angles. What becomes increasingly clear is that technology is not merely a set of objects; it is also a way in which human beings engage with the world. It shapes how we think, how we live, and how we relate to nature and one another. Technology is, in this sense, a worldview or a lens through which humanity has perceived and acted upon the world at different moments in history. The philosophy of technology invites us to reflect critically on this worldview: to ask not only what technology is but also how it shapes our lives, informs our ethics, and influences our collective future.

- In the Enlightenment, technology and technical modes of thought became 'rational' based on their utility

In his book *Critical Theory of Technology* (1991), Feenberg observes that the European Enlightenment challenged traditional customs and myths that could not be explained or justified rationally. It demanded that all customs and institutions justify themselves as useful to humanity in order to remain legitimate. Under the impact of this demand for self-justification with regard to utility/usefulness, science and technology became the new basis for belief. According to him, in our times, science and technology "reshape the culture gradually to be what we think of as 'rational'." This led technology to become omnipresent and dominant everywhere, with technical modes of thought predominating over all other modes of thought.

- Science is about knowledge-seeking, and technology is about usefulness

Andrew Feenberg makes a distinction between science and technology by attributing knowledge to the former and usefulness to the latter. In his article "What Is Philosophy of Technology," Feenberg (2003) observes, "Science and technology share the same kind of rational thinking based on empirical observation and knowledge of natural causality, but technology is not concerned with truth but with usefulness. Where science seeks to know, technology seeks to control." He also observes how 'scientific and technical rationality has become a new culture.'

- Shift from considering the 'usefulness' of technology to exploring the world and life it creates in modern society

As to why the philosophy of technology matters, Feenberg (2002) states that humanity has moved from the idea of 'usefulness' with regard to technology "to the question of the kind of world and the way of life that emerges in a modern society. Insofar as such a society is technological at its basis, the issues raised in this larger questioning concern the field of philosophy of technology. We need to explain ourselves today, and the midst of technology and technical knowledge itself cannot help us. The philosophy of technology belongs to the self-awareness of a society like ours. It teaches us to critically evaluate what we take for granted, specifically, rational modernity."

## 4.1.4. Key Philosophical Questions on Technology

### 4.1.4.1 Imitation of Nature or Extension of Human Organs?

- Is technology merely an imitation of nature, or is it an extension of human capabilities?

Whether technology is an imitation of nature or an extension of humans and their capabilities has been two frameworks or ontological orientations in the field of philosophy of technology. The view that technology is an imitation of nature is a classical view rooted in Aristotle and ancient philosophy. Aristotle in the *Physics* states that "art imitates nature" (techne mimesis phuseos). The idea is that human-made artifacts imitate natural processes; for example, a prosthetic limb mimics a biological one. According to this view, technology follows natural principles; it observes how nature solves problems and attempts to recreate those methods in controlled, human-directed ways.

- Modern philosophy views technology as extending human capacities rather than merely imitating nature

Now, the view that technology is an extension of humans and their faculties is a modern perspective, developed especially by 19th and 20th-century philosophers like Ernst Kapp, Marshall McLuhan, David Rothenberg, and Philip Brey. According to this view, technology is not merely copying nature; rather, it is projecting or extending human capacities into the world. Ernst Kapp (1877) coined the phrase that tools are 'organ projections'—a hammer is an extension of the fist, a telescope of the eye, a computer of memory and thinking. Similarly, McLuhan (1964) argued that weapons such as bows, spears, and knives are extensions of hands, nails, and teeth.

Likewise, clothing is an extension of the skin, extending its function of bodily heat control and protection, and the wheel is seen as an extension of 'feet in rotation'. In this view, technology emerges from human limits, that is, our finitude, rather than simply modelling after nature. To clarify, a crane is not just like an animal lifting heavy things; it is an extension of our own muscles to lift things we otherwise could not.

- Brey emphasizes technology as extending human faculties

In his article *Theories of Technology as Extension of Human Faculties*, Brey (2000) draws on thinkers such as Marshall McLuhan, Ernst Kapp, and David Rothenberg to argue that technological artefacts should be understood as man-made extensions and enhancements of human faculties and organs. The basic idea is that human beings have limited capacities: we have limited visual powers, limited muscular strength, and limited resources for storing information. As Brey (2000) explains, "technical objects extend the human organism by replicating or amplifying bodily and mental abilities." The underlying point of difference between these two approaches to the nature of technology is the source and model of technology: is it nature ('imitation') or humans ('extension')?

### 4.1.4.2 Instrumentalism, Substantivism and Determinism: Theories of Technology

- Instrumentalism sees technology as a tool for human ends, while substantivism views it as an autonomous force shaping society and values

Different theories of technology can be understood as falling into two broad categories: instrumental and substantive theories of technology. The instrumental theory considers technology simply as a tool or instrument of the human species through which we satisfy our needs. In contrast, the substantive theory attributes, as Feenberg (2003) argues, "an autonomous cultural force to technology overriding all traditional or competing values." The fundamental difference, therefore, is that the instrumental theory views technology as subservient to values established in social, cultural, and political spheres, whereas the substantive theory regards technology as a powerful and autonomous force, independent of pre-existing social values, and often creating or reshaping those very values.

- Instrumentalism focuses on human use of technology, while substantivism emphasizes its broader impacts on humanity and nature

To put it more clearly, the instrumental theory of technology assumes that technology does not necessarily change an organisation's or a culture's practices. This theory focuses on people's use of technology rather than on the technology itself. It is the most widely accepted, standard modern view and remains the dominant perspective in modern governments, on which many governmental and policy decisions rely. In contrast, the substantive theory claims, as Feenberg (2003) argues, that "what the very employment of technology does to humanity and nature is more consequential than its ostensible goals."

- Instrumentalism assumes human control and the value neutrality of technology

One notable point is that instrumental theory is grounded in two crucial ideas: human control over technology and the value neutrality of technology. That is, the notion that technology is merely an instrument presupposes that humanity has control over it and that it has no intrinsic value except what we attribute to it. According to Feenberg (2003), instrumental theory corresponds to the liberal faith in progress, which is a prominent feature of mainstream Western thought.

- Substantivism views technology as influential, and determinism treats technology as fully autonomous

While instrumentalism sees technology as value-neutral and fully under human control, substantivism challenges this by emphasising that technology has intrinsic effects as a powerful and often autonomous force that reshapes society, culture, and values, sometimes creating new values independently of direct human intentions (Feenberg, 2003). In this sense, substantivism is a critical progression from instrumentalism, stressing that technology is never "just a tool" but can itself generate significant transformations. Technological determinism goes further by asserting that technology becomes fully autonomous, directly shaping human behaviour, institutions, and historical development, leaving minimal room for human agency. Thus, the three views differ primarily in terms of the locus of control: from human control (instrumentalism) to technology as a powerful, autonomous force influencing humans and society and creating values at times (substantivism), to technology as a fully autonomous causal agent that determines the course of human life and society (determinism).

Determinists believe that technology is not under human control; rather, it is autonomous in the sense that it shapes human behaviour and society according to the demands of efficiency and progress. This view has been widely held in the social sciences, especially after Karl Marx argued that technological advancement is a driving force of historical change. Feenberg (2003) explains the core points of the deterministic view:

- Determinism views technology as autonomous, producing human behaviour and society rather than being controlled by humans

"Technological determinists usually argue that technology employs advancing knowledge of the natural world to serve universal features of human nature such as basic needs and faculties. Each worthwhile discovery addresses some aspect of our nature, fulfils a basic need or extends our faculties. Food and shelter are such needs and motivate some advances. Technologies like the automobile extend our feet while computers extend our brains. Technology is rooted on one side in knowledge of nature and on the other in generic features of the human species. It is not up to us to adapt technology to our whims but, on the contrary, we must adapt to technology as the most significant expression of our humanity."

- Does technology drive social change, or is it shaped by social needs and values?

In short, the central question is this: does the invention of the steam engine or the computer cause social change, or do social needs and values determine the development of such technologies? Technological determinism emphasises the former, suggesting that once a technology is invented, it sets in motion an inevitable series of social transformations. To accept this view as such is controversial, as it can lead to fatalism and depoliticise technological choices.

## Summarized Overview

The philosophical inquiry into technology, rooted in classical distinctions such as *techne* and *episteme*, has gained renewed relevance in the context of industrialisation and digital transformation. A central debate in the philosophy of technology is between instrumentalist and non-instrumentalist perspectives. Instrumentalism treats technology as a neutral tool serving human purposes, assuming human control and value neutrality. In contrast, non-instrumentalist approaches highlight the intrinsic power of technology to shape society, culture, and values. Substantivist thinkers, including Heidegger, argue that modern technology is a mode of revealing that transforms reality, often reducing nature and humans to resources. Technological determinism takes this further, asserting that technology autonomously drives social change. Critics of determinism argue that it underestimates human agency and the socially contingent nature of technological development. Andrew Feenberg's critical theory provides an alternative framework, emphasising that technology is socially shaped, politically significant, and open to democratic transformation

## Self-Assessment

1. How does Aristotle distinguish between physis and poiesis, and what implications does this have for explaining technology?
2. What is the difference between techne and episteme in classical Greek thought?
3. Summarise the key distinctions between instrumentalist, substantivist, and deterministic theories of technology.
4. In what way do thinkers like Ernst Kapp and Marshall McLuhan conceptualise technology as an extension of human faculties?

## Assignments

1. Compare and contrast the ancient Greek conception of techne with the modern explanation of technology. Use examples to support your argument.
2. Critically evaluate Andrew Feenberg's position on the relationship between science, technology, and modern rationality.
3. Discuss the implications of technological determinism for democratic control over technological development. Can society still choose its technological future?
4. Drawing on the views of Aristotle, Heidegger, and Kapp, write an essay on how different philosophical traditions interpret the origin and essence of technology.

## Reference


1. Brey, P. (2000). Technology as Extension of Human Faculties. In C. Mitcham (Ed.), *Metaphysics, Epistemology, and Technology* (*Research in Philosophy and Technology*, Vol. 19, pp. 59–78). JAI Press.
2. Feenberg, A. (2002). *Transforming Technology: A Critical Theory Revisited*. Oxford University Press.
3. Ihde, D. (1993). *Philosophy of Technology: An Introduction*. Paragon House.
4. Nye, D. E. (2006). *Technology Matters: Questions to Live With*. MIT Press.
5. Parry, R. (2008). *Episteme and Techne*. In E. Zalta (Ed.), The Stanford Encyclopedia of Philosophy (Fall 2008 Edition).
6. Winner, L. (1977). *Autonomous Technology: Technics-Out-of-Control as a Theme in Political Thought*. MIT Press.




## Suggested Reading


1. Dusek, V. (2006). *Philosophy of Technology: An Introduction*. Blackwell Publishing.
2. Feenberg, A. (1999). *Questioning Technology*. Routledge.
3. Kapp, E. (1877). *Foundations of a Philosophy of Technology*. Braunschweig: Westermann.
4. Heidegger, M. (1977). *The Question Concerning Technology and Other Essays*. Harper & Row.
5. Mitcham, C. (1994). *Thinking Through Technology: The Path Between Engineering and Philosophy*. University of Chicago Press.
6. De Boer, B., & Zwier, J. (Eds.). (2021). *Phenomenology and the Philosophy of Technology*. Routledge.

## Space for Learner Engagement for Objective Questions

Learners are encouraged to develop objective questions based on the content in the paragraph as a sign of their comprehension of the content. The Learners may reflect on the recap bullets and relate their understanding with the narrative in order to frame objective questions from the given text. The University expects that 1 - 2 questions are developed for each paragraph. The space given below can be used for listing the questions.

# UNIT 2
# Heidegger on Technology: Modern Technology as a Way of Revealing

## Learning Outcomes

By the end of this unit, the learner will be able to:

- explain Heidegger's critique of the instrumental and anthropological definitions of technology
- distinguish between the concepts of ready-to-hand and present-at-hand in Heidegger's analysis of tool use
- interpret the meaning of enframing and how it reveals the modern technological worldview
- compare Heidegger's notion of techne and poiesis with the character of modern technology
- evaluate the relevance and limitations of Heidegger's views through later thinkers like Don Ihde and Andrew Feenberg



## Background

The philosophy of technology underwent a transformative shift with the intervention of Martin Heidegger. Moving beyond earlier instrumental or anthropological views, Heidegger approaches technology not as a neutral tool or human activity but as a fundamental mode through which the world is revealed. Drawing from ancient Greek concepts such as techne and poiesis, Heidegger's inquiry challenges the assumptions of modern technological rationality, which frames nature as mere resource or standing reserve. His distinction between ready-to-hand and present-at-hand modes of being, introduced in *Being and Time* (Heidegger, 1927), laid the foundation for explaining how humans encounter and relate to the world through tools.

Later, in *The Question Concerning Technology*, Heidegger deepens this reflection by exploring the ontological essence of technology as enframing (Gestell). This concept points to the historical mode in which modern humanity reveals reality: not by allowing things to be as they are, but by ordering and controlling them as resources. Heidegger's view, while influential in contemporary debates, faced both strong critiques and extensions from thinkers such as Andrew Feenberg and Don Ihde, who argue for a more contextual and socially embedded view of technological mediation.

## Keywords

Enframing, Standing-Reserve, Revealing, Ready-to-Hand, Present-at-Hand, Poetic Revealing, Forcing-in-to Being

## Discussion

### 4.2.1 Introduction: From Tools to Ontology

- Technology as a mode of revealing reality

Martin Heidegger approaches technology not in terms of its usefulness or instrumentality as specific tools, but in terms of its ontological meaning – how technology reveals the world to us and shapes human understanding of Being. That is, how does it shape our understanding of ourselves and the world? Heidegger builds his theory of technology by sharply criticising the traditional conceptions of technology as instrumental (human-controlled) or 'human activity' and presents his own view that modern technology is a distinctive way in which Being itself is disclosed to us.

- Instrumental and anthropological views see technology as means to ends, but Heidegger seeks its deeper essence

Heidegger (1977) refers to the current conception of technology as "a means to an end" and "a human activity" as the instrumental and anthropological definitions of technology. According to him, these two definitions belong together: "For to posit ends and procure and utilise the means to them is a human activity. The manufacture and utilisation of equipment, tools, and machines, the manufactured and used things themselves, and the needs and ends that they serve, all belong to what technology is." In other words, both of these conceptions lead to the instrumentality of technology. Heidegger emphasises that neither definition reveals the essence of technology. His philosophical inquiry focuses on the essence of technology itself, rather than on technological artefacts.

For Heidegger, technology is the fundamental fact or force in the modern condition. In his first major writing, *Being and Time* (1927), Heidegger analyses our comportment towards objects in terms of two modes of being: ready-to-hand and present-at-hand. That is, there are two modes in which we are engaged with objects in the world. The present-at-hand mode is the conventional notion of objects as substantial entities, observed

- Distinction between ready-to-hand and present-at-hand modes of engaging with objects in the world

- Ready-to-hand objects are experienced through use, becoming noticeable only when they malfunction

- A hammer is ready-to-hand when used seamlessly and becomes present-at-hand only when it breaks

- Present-at-hand is theoretical observation, while ready-to-hand reflects practical, engaged use in everyday experience

or thought of as independent and detached from us. Traditional philosophy, especially since Descartes, treated all objects in this manner. This mode assumes a subject-object dichotomy, where objects are understood as standing independently over and against the subject, a view that has dominated traditional philosophy since Descartes. Here, objects are perceived by the senses, as empiricists claim, or conceived by the intellect, as rationalists argue, always as separate and distinct from us.

In contrast, the ready-to-hand object of use is not encountered as an independent entity but as a means through which we work, act, and engage in practical activity. This mode corresponds to tool use, in which objects are understood as means to our ends. As Dusek (2006) explains, "the object exists in its role in our action." A tool or object that is ready-to-hand is transparent to us in our everyday tasks; its presence withdraws, as Heidegger puts it, as we focus on the activity it enables. It becomes noticeable only when it malfunctions or breaks, at which point it shifts into the present-at-hand mode, standing before us as an object of attention.

Heidegger famously illustrates the ready-to-hand mode of objects with the example of a hammer: when we are absorbed in hammering nails, our attention is directed toward the task, not the tool. There is only a preconscious relation between us and the tool at the time of activity. Only when the hammer breaks or fails to function as expected do we turn our focus to the hammer itself, rather than the goal it typically serves.

In other words, 'present-at-hand' refers to the detached, theoretical observation of an entity as an object with properties, such as a carpenter examining a broken hammer to figure out what's wrong with it. In contrast, 'ready-to-hand' describes entities encountered in a practical, functional, and engaged way, like a skilled carpenter's hammer being used effortlessly for building. Readiness-to-hand is considered primary, as our everyday experience is predominantly practical, with the present-at-hand mode emerging when our practical engagements are disrupted. In short, this tool-like mode of existence was central to Heidegger's earlier philosophy. In his later philosophy, technology itself becomes a subject of reflection.

### 4.2.2 The Essence of Technology is Not Technological

Heidegger (1977) asserts that "the essence of technology is by no means anything technological," just as the essence

- The essence of technology lies in how it reveals the world, not in the tools themselves

of a tree is not itself a tree. Both definitions mentioned above are correct; that is, technological objects are means for our ends and are built and operated by human beings. However, the essence of technology is something deeper and goes beyond that. This means the true nature of technology cannot be understood by examining particular devices or tools. Instead, we must investigate the real essence of technology by considering how technology discloses or reveals the world to us.

- Modern technology shifts from poetic revealing to forceful ordering of nature as standing-reserve

For Heidegger, the ancient Greek notion of techne is central. Techne refers to the skilled knowing involved in craft, art, or poetry. It means making or bringing-forth (poiesis) something into presence. In this sense, ancient technology was a form of revealing the truth of things. Modern technology, however, represents a break from this older, poetic mode of revealing. It is not a gentle bringing-forth but a forceful challenging-forth. Nature is no longer allowed to emerge in its own way but is ordered and extracted as a 'standing-reserve' (Bestand), a stockpile of raw materials or resources to be mobilised in technical processes and waiting to be used. This transformation marks a shift not just in our tools but in our way of being in the world.

### 4.2.3 Modern Technology as Enframing: A Mode of Disclosing Reality

- Enframing interprets everything, including humans, as resources; the modern technological worldview

The central concept in Heidegger's analysis of modern technology is Gestell, often translated as "enframing." Enframing is a mode of revealing in which everything, including human beings, is interpreted as a resource to be stored and used. It represents the essence of modern technology, not just as a set of tools, and shapes how we explain and interact with the world. A river becomes a 'hydroelectric power source', the earth becomes a coal mine, and even humans are seen as 'human resources.' Heidegger warns that this reductionist view is dangerous because it obscures other, richer ways of relating to Being. However, he also notes that enframing is not something we choose or enact; rather, it is a historical unfolding of Being itself. We live within this mode of revealing, and we cannot escape it simply by changing our attitude.

- Technology as a way of revealing reality is relational and historically shaped

Technology is not neutral. Rather, Heidegger says, it must be understood as "a way of revealing." By "revealing," he means uncovering or bringing forth what is hidden. For Heidegger, what we call "reality" is not given in the same way across all times and cultures. Reality is not an absolute that human beings can know once and for all; instead, it is relational. 'Reality' is not something absolute that human beings can ever know once and for all; it is relative. It exists only in relations. In other words, our understanding of the world, our comprehension of 'being', and what it means 'to be' develops through the ages.

We enter into a particular relation with reality at different historical moments, and through this relation, reality is 'revealed' to us in specific ways. In the modern era, technology becomes the dominant mode of revealing that characterises our time. Today, Being has the character of a technological framework through which humans approach the world in a controlling and dominating manner. Technology embodies a specific way of revealing in which humans assert power over reality, seeing the world as raw material available for production, use, and manipulation. Whereas the 'making' of something in ancient Greece was understood as 'helping something to come into being', modern technology involves a kind of 'forcing into being.'

- Modern technology reveals reality by asserting control, transforming the world into resources to be used

Heidegger (1977) affirms that if we inquire into what technology is (which is understood traditionally as a means), we arrive at a deeper insight: technology is a form of revealing. He writes: "The possibility of all productive manufacturing lies in revealing. Technology is therefore no mere means. Technology is a way of revealing. It is the realm of revealing, i.e., of truth." To explain this, Heidegger examines the origin of the word technology, which comes from the Greek *technikon*, derived from *techne*. In ancient Greece, *techne* did not merely refer to technical skills or craftsmanship; it also encompassed the arts of the mind and the fine arts. For Heidegger, *techne* is a form of *bringing-forth* (*poiesis*), a poetic mode of revealing that allows beings to emerge into presence.

- Technology, rooted in techne, is a poetic mode of revealing that brings beings into presence, for Heidegger

More importantly, techne was closely connected to episteme, a term for knowing in the broadest sense. Both techne and episteme implied a kind of knowing that involved being deeply familiar with something; to be at home in it. Such knowing was not just theoretical. It was an active, experiential opening up of the world, which Heidegger calls "bringing-forth" (poiesis). In this sense, techne is poetic; it brings something into presence, lets it appear, and reveals it. Therefore, according to Heidegger, technology is not simply about producing things. It is a mode of revealing, a process through which truth emerges and reality is made visible to us.

- Techne, linked to episteme, frames technology as a poetic mode of revealing, not merely production

Dusek (2006) explains: "Heidegger claims that modern technology defines the present epoch of humanity just as religion

- Modern technology enframes reality, making everything a resource.

defined the orientation to the world of the Middle Ages. Modern technology differs from previous crafts (although it grows out of them) insofar as it 'enframes' or 'stamps' everything with its orientation. All of nature becomes a 'standing reserve,' a source of resources, in particular a source of energy. This enframing cuts us off from appreciating non-technological ways of apprehending the world." We become so entangled in the technological way of thinking or technological attitude.

- Feenberg and Ihde stress technology's social and experiential dimensions.

Later thinkers such as Andrew Feenberg and Don Ihde have critiqued and revised Heidegger's philosophy of technology. Feenberg (2002) challenges Heidegger's notion of *Gestell* (enframing) as an inescapable historical destiny, arguing instead that technology is not autonomous but shaped by social and political forces and thus open to democratic transformation. Meanwhile, Ihde (1990) rejects Heidegger's monolithic and abstract treatment of 'technology' and instead focuses on how particular technologies are experienced in concrete contexts. His post-phenomenological approach emphasises the diverse ways technologies mediate human experience.



## Summarized Overview

Heidegger critiques the dominant instrumental and anthropological definitions of technology, seeing it as a "means to an end" or a "human activity," and arguing that such conceptions obscure the true essence of technology. Through his concepts of ready-to-hand and present-at-hand, Heidegger reconfigures how we relate to technological objects in everyday life, emphasising that our primary mode of interaction is not theoretical detachment but practical engagement. This leads into his more radical thesis: technology is a "mode of revealing," a way in which truth or Being comes into presence. Ancient techne, in this view, allowed beings to emerge poetically, whereas modern technology challenges nature, ordering it into a calculable "standing-reserve" for human use.

The heart of Heidegger's critique lies in his concept of enframing, a dominant mode of disclosure in the modern age where everything, including humans, is viewed as a resource. Far from being neutral, technology structures our very way of encountering the world, narrowing our access to other, more poetic or meaningful modes of existence. While Heidegger does not offer a technological solution, he calls for a more thoughtful engagement with technology—one that remains open to alternative ways of revealing truth. Later thinkers such as Feenberg and Ihde expand and contest Heidegger's views: Feenberg argues for the democratic shaping of technology, while Ihde emphasises concrete, plural technological mediations rather than a single, totalising technological destiny. These developments point toward a post-phenomenological turn that retains Heidegger's depth but resists his determinism.

## Self-Assessment

1. What does Heidegger mean by saying "the essence of technology is nothing technological"?
2. How do ready-to-hand and present-at-hand modes influence our relation to tools and objects?
3. Explain Gestell or enframing. How does it function in the modern world?
4. In what way is modern technology different from the ancient Greek notion of techne?

## Assignments

1. Discuss Heidegger's claim that technology is a "way of revealing" and not just a human activity.
2. Analyse the concept of enframing in *The Question Concerning Technology*. What dangers does Heidegger identify in this mode of revealing?
3. Compare Heidegger's distinction between techne and modern technology. How does this comparison help us explain technological thinking today?
4. How does the example of the hammer illustrate Heidegger's phenomenology of tool-use?
5. Critically assess the view that modern technology determines our way of being in the world, using insights from Heidegger and his critics.



## Reference


1. Heidegger, M. (1927). *Being and Time*. Trans. J. Macquarrie & E. Robinson. Harper & Row.
2. Heidegger, M. (1977). *The Question Concerning Technology and Other Essays*. Trans. W. Lovitt. Harper & Row.
3. Dusek, V. (2006). *Philosophy of Technology: An Introduction*. Blackwell.
4. Feenberg, A. (1999). *Questioning Technology*. Routledge.
5. Ihde, D. (1990). *Technology and the Lifeworld: From Garden to Earth*. Indiana University Press.
6. Feenberg, A. (2002). *Transforming Technology: A Critical Theory Revisited*. Oxford University Press.

## Suggested Reading


1. Mitcham, C. (1994). *Thinking through Technology: The Path between Engineering and Philosophy*. University of Chicago Press.
2. Verbeek, P.-P. (2005). *What Things Do: Philosophical Reflections on Technology, Agency, and Design*. Penn State University Press.
3. Ihde, D. (2002). *Bodies in Technology*. University of Minnesota Press.
4. Jonas, H. (1984). *The Imperative of Responsibility: In Search of an Ethics for the Technological Age*. University of Chicago Press.
5. Scharff, R. C., & Dusek, V. (Eds.). (2014). *Philosophy of Technology: The Technological Condition* (2nd ed.). Wiley-Blackwell.




## Space for Learner Engagement for Objective Questions

Learners are encouraged to develop objective questions based on the content in the paragraph as a sign of their comprehension of the content. The Learners may reflect on the recap bullets and relate their understanding with the narrative in order to frame objective questions from the given text. The University expects that 1 - 2 questions are developed for each paragraph. The space given below can be used for listing the questions.

# UNIT 3
# Phenomenology of Technology

## Learning Outcomes

By the end of this unit, the learner will be able to:

- explain the core ideas of post-phenomenology and distinguish it from classical phenomenology
- analyse how technologies mediate human-world relations through various forms of embodiment, perception, and interpretation
- interpret the notion of the 'technological lifeworld' and evaluate how everyday experiences are shaped and structured by technological artefacts
- assess the concept of technological hermeneutics and its role in explaining the interpretative dimensions of science
- discuss the interrelation between technoscience and embodied experience, and how technological artefacts contribute to shaping scientific practices and social meanings



## Background

The relationship between humans and technology has long been a subject of philosophical inquiry, evolving alongside the very technologies that shape our lives. Classical approaches to technology often viewed it as a neutral set of tools or instruments, that is, means to human ends. However, contemporary philosophy of technology, particularly since the mid-20th century, has moved beyond this instrumentalist view. Thinkers influenced by phenomenology, post-phenomenology, critical theory, and Science and Technology Studies (STS) have radically reconceptualised technology as an active and formative force in human experience, knowledge, culture, and politics.

## Keywords

Post-phenomenology, Technological Mediation, Embodiment Relations, Technological Lifeworld, Technoscience, Technological Hermeneutics

## Discussion

### 4.3.1. Phenomenology of Technology: A Historical Overview

- Post-phenomenology emerged from debates on the social and interpretive dimensions of science and technology

In his book *Post-phenomenology and Technoscience*, Ihde (2009) outlines evolving approaches to science and the emergence of the philosophy and phenomenology of technology. Central to this trajectory is the episode known as the "science wars" of the 1990s in the Anglo-American academic world, an intense debate between natural scientists and scholars from the humanities and social sciences. At the heart of these debates was a fundamental question: Is scientific knowledge purely objective, or is it shaped by social, cultural, and interpretive frameworks? These discussions highlighted deeper philosophical tensions regarding the interpretation of science and technology and set the stage for the development of post-phenomenology as a nuanced approach bridging empirical practice with philosophical reflection.

- Broader shifts in the philosophy of science and technology in the twentieth century

Ihde (2009) traces broader shifts in the philosophies of science and technology throughout the 20th century. Early in the century, dominant approaches split between logical positivism, exemplified by the Vienna Circle, and phenomenology, with the Göttingen School and Husserl treating phenomenology as a rigorous science grounded in logic and mathematics. According to Ihde, "Phenomenology, from its beginnings, was one of the players in the early science interpretation wars." For a time, both approaches aimed to model philosophy on the methods of science. After World War II, positivism gained prominence in the United States, where emigrant philosophers largely dominated the field, equating philosophy with the philosophy of science. From the 1930s through the 1950s, logical positivism, or logical empiricism, remained the dominant approach in the philosophy of science. It conceived science as a rigorous, logic-driven enterprise that systematically generated theories and verified them through logical coherence and empirical testing.

By the 1950s and 1960s, a new anti-positivist approach to

- By the 1950s–60s, science was seen as historically and contextually interpreted, with paradigm shifts shaping its development.

the philosophy of science emerged, with Thomas Kuhn and others emphasising the roles of history and scientific revolutions in shaping scientific practice. Science came to be understood as an "interpreted science," where historical particularity and specificity are integral to its development. Ihde (2009) observes: "This image of science began to be enriched by historical sensitivity. Rather than a linear, cumulative historical trajectory, the anti-positivists projected a narrative filled with 'paradigm shifts' and punctuated discontinuities."

- By the 1970s, explorations of the social and political dimensions of science emerged

By the 1970s, sociologists of scientific knowledge began exploring the social and political dimensions of science through approaches such as social constructionism and actor-network theory. Science came to be understood as a particular social practice rather than a purely abstract theory, with its results seen as negotiated and constructed. In the 1980s, new philosophies of technology emerged; post-Heideggerian, post-Ellul, and post-Marxian approaches emphasised that science itself is embodied in technological instruments and laboratory practices. By the 1990s, feminist philosophers highlighted the patriarchal and gendered assumptions embedded in scientific practice, revealing that science was frequently gendered in cultural practice.

### 4.3.2 Don Ihde's Post-Phenomenological Turn

- Post-phenomenology adapts classical phenomenology to address 20th-century transformations in science, technology, and their philosophical interpretation

Post-phenomenology, as developed by Ihde, is rooted in classical phenomenology but undergoes critical and deliberate adaptations and changes to address historical transformations in science and technology in the twenty-first century. With the phrases 'post-phenomenology' and 'technoscience,' Ihde seeks to address the radical transformations that the twentieth century brought not only in science and technology themselves but also in the philosophies and interpretations of these domains. He emphasises that these changes are not limited to practices but extend to how science and technology are understood, conceptualised, and engaged with philosophically.

According to Ihde (2009), post-phenomenology is pragmatism plus phenomenology. Regarding pragmatism, Ihde (2009) argues that all philosophers of technology emerged from the praxis tradition, such as Marxism and critical theory, phenomenology and existentialism, and pragmatism, which focused on a thematisation of human experience in relation to technologies. Pragmatism, Rorty (1982) states, is "the vocabulary of practice rather than theory, of action rather than

- Ihde links post-phenomenology to pragmatism and highlights technology's role in human experience

contemplation, in which one can say something about truth." It is the anti-essentialism applied to notions such as "truth," "knowledge," "language," "morality," and similar objects of philosophical theorising. Ihde (2009) observes: "Technology often was cast in a dystopian mode. It was blamed for human alienation from nature, it was seen as the cause of the decline of Kultur, that is, elite culture, it stimulated the rise of mass man and popular culture, and it pointed to a levelling of all things. In its sociological form, derived from the thought of Max Weber, it also was thought to play a role in the disenchantment of nature and the desacralisation of the earth."

- Post-phenomenology studies technologies in their concrete, historical, and lifeworld contexts

Post-phenomenology, instead of taking an essentialist approach to technology (the view that technological artefacts are given), analyses their concrete, historical development and formation. As Ihde (2009) points out, post-phenomenology is "a step into the examination of technologies in their particularities. It is the step away from a high altitude or transcendental perspective and an appreciation of the multidimensionality of technologies as material cultures within a lifeworld."

## 4.3.3 Experiential Turn in the Philosophy of Technology

As we have seen, classical approaches to the philosophy of technology, particularly those shaped by thinkers like Heidegger (1977), often viewed technology as a metaphysical or monolithic force. Such frameworks, in their search for the essence of technology (a kind of metaphysical essentialism), tended to emphasise the danger of technology dominating human existence, as seen in Heidegger's idea of enframing as the essence of modern technology. In contrast, the phenomenology of technology, especially as developed by Ihde (2009), takes a decisive turn towards the experiential and relational dimensions of technology. It raises concrete and everyday questions such as: What is the role of technology in our culture and our lived experience? How do technological artefacts shape our perception, bodily engagement, and relations with the world? How do technological instruments mediate and transform human knowledge and action?

- The focus shifts from technology's essence to its everyday, experiential, and relational impacts on human life

- Ihde builds on classical phenomenology and emphasises the technological lifeworld as the foundation of human experience

Ihde's turn towards experience has deep roots in classical phenomenology, particularly in the works of Husserl and Merleau-Ponty. Husserl introduced the concept of the lifeworld, the pre-reflective, taken-for-granted world of everyday experience that forms the background of all scientific and theoretical knowledge. This lifeworld is intimately lived and experienced by human beings situated in a world; it is neither distant nor abstract, nor is it merely an object of critique.

- Merleau-Ponty shows that humans and their world are inseparably intertwined through lived experience

Merleau-Ponty (1962), in his influential work *Phenomenology of Perception*, extends Husserl's ideas by emphasising the embodied nature of cognition and perception. He challenges the Cartesian mind–body dichotomy and its assumption that cognition is a purely mental or representational activity occurring in an isolated mind. Merleau-Ponty replaces the 'subject–object' distinction with the notion of human beings and their world in an intertwined relationship. We are body-subjects, and our cognition is inextricably tied to our embodied existence. Perception is always shaped by our bodily orientation, capabilities, and situatedness in the world. The body is not merely a vessel or object in space to be observed; it is a lived body, a dynamic centre of experience. In other words, human beings cannot be conceived apart from their relations to the world, and the world cannot be conceived apart from people's relations to it.

- Consciousness is always directed, embodied, and relational; Ihde's foundation for the phenomenology of technology

The fundamental structure of consciousness, or what is called "intentionality" in phenomenology, points to the inherent connectedness described above. Consciousness is always consciousness of something; it is directed, situated, and open to the world. This inter-relational openness is not neutral or abstract but shaped through bodily engagement. Drawing on these foundational insights, such as intentionality, inter-relationality, and embodiment, Don Ihde (1990) develops his phenomenology of technology.

- Technologies become part of our embodied experience, extending perception, knowledge, and action

Along the same lines as the idea that objects are not external entities waiting to be observed and analysed, Ihde (1990) argues that technologies are not merely external tools used by a disembodied subject; rather, they become part of our embodied experience. They extend, mediate, and reshape how we perceive, know, and act in the world. Merleau-Ponty (1962) illustrates this with the example of the blind man's cane: "The blind man's stick has ceased to be an object for him and is no longer perceived for itself; its point has become an area of sensitivity, extending the scope and active radius of touch and providing a parallel to sight. In the exploration of things, the length of the stick does not enter expressly as a middle term, as an entity-in-itself; rather, the blind man is aware of it through the position of objects around it."

While Ihde (2009) states that Merleau-Ponty made only limited contributions to the phenomenology of technology per se, he emphasises that Merleau-Ponty contributes to a "very subtle and nuanced discussion of the role of body, perception, and action—that is, embodiment through technology," particularly in *Phenomenology of Perception* (1962). On this basis, Ihde introduces his concept of the technological lifeworld in the twentieth century, a world in which our experience is always already technologically mediated. Just as Merleau-Ponty demonstrated that the body is the vehicle of being-in-the-world, Ihde shows that technologies become incorporated into our "body schema," to use Merleau-Ponty's term, functioning as instruments through which the world is known, interpreted, and disclosed to us.

- Ihde builds on Merleau-Ponty to show that technologies become part of our embodied experience

## 4.3.4 On Human-Technological Relations

Ihde (2009) explains embodiment in the context of technological artefacts as follows: "Embodiment is, in practice, the way in which we engage our environment or 'world,' and while we may not often explicitly attend to it, many of these actions incorporate the use of artefacts or technologies." Ihde explains human-technological relations and examines the role of technology in the human lifeworld on two grounds: experience and culture. In his chapter "Don Ihde: The Technological Lifeworld," Peter-Paul Verbeek (2001) explains Ihde's dual approach to technology: "On the level of experience he (Ihde) enquires into the role that technological artefacts can play in the relations of human beings to reality; on the cultural level, he inquires into the relations between technological artefacts and culture."

- Ihde views human-technological relations on two levels: how technologies shape our everyday experiences and how they influence culture

Since phenomenology primarily focuses on the structure of human experience, Ihde (1990) centres his analysis on how this experience is structured in relation to technological artefacts. Experience becomes the focus because it is the place where, as Verbeek (2001) notes, "mutual relations between human beings and their world are localized". Ihde analyses human experience in terms of perception, as this is the key site for explaining "the relation between human beings and their world." Verbeek (2001) interprets Ihde's point as follows: "Perception is, as it were, the interweaving of both: in perception, human beings and world—or subject and object for that matter—are not separated but always intertwined. Only afterward, when a perception is described and not enacted, does it make sense to separate out a perceiver and a perceived, or a subject and an object, as one says. In the perceiving itself, that cannot be done, since to perceive is to perceive the world.

- How experience, especially perception, intertwines humans, technologies, and the world

In experiencing, people are as much 'in' the world as the world is 'in' them: they cannot be separated."

- Three relations of technology: mediation, alterity, and background

Verbeek (2001) explains that, for Ihde, human beings can relate to technological artefacts in three primary ways: the relation of mediation, alterity relation, and background relation. The relation of mediation is one in which our perception is mediated by a technological artefact. In this relation, we are not directly connected to the world but do so via an artefact, as in the case of wearing glasses. In the second relation, alterity relations, our connection is not through an artefact to the world but to the artefact itself. The third kind of human-technology relation, according to Ihde, is the background relation, in which technological artefacts shape our relationship to reality by remaining in the background.

- Technologies mediate experience

Verbeek investigates how technologies mediate our experiences in daily life, for instance, when we recall events via photographs or communicate with each other via telephone. In another case, what happens to our perceptions when they are enacted through technologies? The point is that we are not directly present in bodily-sensory experience with the world in the cases mentioned, but rather through technological artefacts. He illustrates this by relying heavily on examples of the 'handiness' or 'readiness-to-hand' of a hammer while in use and the blind man's cane, drawing from Heidegger and Merleau-Ponty, respectively. Verbeek (2001) explains Heidegger's point about tool use: "Someone who is hammering is not concerned with the hammer but rather with what is being done, or made with the hammer. Only when human beings are not concerned with the tool but rather with the work that they are doing with their tools do these tools become present to them as tools. Tools call attention to themselves only if and when it is impossible to do anything with them."

- A tool is "something in order to"—the idea was expanded as 'technological intentionality.'

From this example, Verbeek (2001) draws three fundamental points. First, according to Heidegger, each tool or piece of equipment in itself is nothing; rather, it is related to a context and is part of a meaningful whole. Second, Heidegger attributes "instrumental intentionality" to tools, meaning a tool is "something in order to," which Ihde later expands to "technological intentionality." Third, and most importantly, Ihde emphasises that "a tool, when used in practical activity (and not in the description of it), is a means of experiencing, rather than an object of experience."

He then shows how this last point is crucial to Merleau-

- Artefacts extend perception; humans perceive the world through objects, not the objects themselves

Ponty's analysis of the role that objects play for human beings. Merleau-Ponty demonstrates how human beings are related 'through objects' to the world, especially in the case of the blind man's cane. Verbeek (2001) explains his view in this regard: "the image of the blind man's cane carries this a step further, making it clear that human beings cannot only extend the spatiality of their lived bodies with the aid of artefacts but perceive with them as well. With his hand, a blind man feels not so much the stick as the street and the objects in the way through the stick. Just as Heidegger's carpenter is not involved so much with the hammer while at work as with the nail to be nailed in place, so a blind person is not truly involved with the cane as with the world through the cane."

- Technologies like eyeglasses or dental probes integrate with the body; (I – technology) → world

This insight is central to embodiment relations. Verbeek offers familiar examples to illustrate this: eyeglasses merge with vision rather than being the object of vision; a dentist's probe becomes an extension of touch. In both cases, technology integrates with the body and perception, becoming an extension of the body that reshapes how we engage with the world. He also notes that Ihde summarises this embodiment structure using the schema: (I – technology) → world.

## 4.3.5 Science as Technological Hermeneutics

- Science is technologically mediated; scientific knowledge is enabled by instruments, making science and technology inseparable

Ihde (1991), in *Instrumental Realism: The Interface Between Philosophy of Science and Philosophy of Technology*, deepens his analysis of the "technological lifeworld" and "technological embodiment" by applying them to the philosophy of science. He introduces the notion of *hermeneutic relations* of technology and challenges the traditional view of science as a purely cognitive or theoretical endeavour. Instead, he argues that scientific knowledge is inherently technologically mediated. This insight leads him to adopt the term technoscience, a concept that breaks down the conventional distinction between science and technology. In Ihde's view, scientific observation and discovery are not independent of technological instruments such as microscopes, telescopes, or simulations; rather, these instruments actively shape what can be known. Thus, science is not simply aided by technology but is materially constituted through it. In other words, science is materially enabled, shaped, and sometimes even determined by technological instruments such as microscopes, satellites, or digital simulations.

Scientific observation, then, is never 'pure' or neutral; rather, it is always mediated through tools. Instruments do

- Scientific observation is always mediated by instruments and determines what can be perceived; technology intensifies theory-ladenness

not merely extend our senses; they transform the very nature of what is observable. For instance, a telescope is not just a tool used after a theory is formed. Rather, it shapes the very data and perception that make theory possible. Thus, the theory-ladenness of observation, a key point in the philosophy of science since Kuhn and Feyerabend, is intensified by technological-ladenness, a central insight of Don Ihde's technological hermeneutics.

- Science is technologically mediated, with instruments shaping what is observable and knowable

This notion of technological embodiment challenges the earlier positivist view of science as an objective, transparent 'mirror of nature.' Instead, science becomes an interpretive, situated practice, a form of hermeneutics where instruments mediate, structure, and even co-constitute what can be known. Ihde argues that technologies are not neutral tools; they actively shape the kinds of questions we can ask and the kinds of answers we can receive. For example, the way the Hubble Telescope visualises distant galaxies is not just an extension of vision but a transformation of how we interpret the cosmos. Thus, science, from this perspective, is not just socially constructed, as argued by social constructionists in the 1970s, but also technologically constructed. Technological hermeneutics pushes us to see that the very ontology of scientific objects or what counts as "real" or "knowable" is inseparable from the technologies through which they are accessed. This marks a radical shift in how we must explain scientific knowledge, not as a mirror of an independent reality, but as a product of complex human-technology-world interactions.



## Summarized Overview

The philosophy of technology has undergone a significant shift from classical essentialist and metaphysical inquiries to more situated, experiential, and empirical analyses of technology's relation to human beings and society. Classical thinkers such as Heidegger understood technology as a revealing force with a singular essence, typified in his notion of enframing, which casts the world as a resource to be ordered and exploited. This line of thought, while offering profound metaphysical insight into the dangers of modern technology, often treats technology as a monolithic and somewhat autonomous force that stands apart from everyday human experience. In contrast, contemporary thinkers such as Don Ihde and Peter-Paul Verbeek critique such essentialism, arguing instead for a relational ontology of technology that emerges through human-technology-world interactions. The post-phenomenological approach thus reorients the discussion from "what technology is" to "how technology is experienced," thereby restoring human agency and phenomenological nuance into the study of the technological condition.

Ihde's phenomenology of technology offers an account of how human-technology relations are not external or secondary but constitutive of experience itself. Drawing on Heidegger and Merleau-Ponty, and in line with Ihde, Verbeek develops a nuanced typology of technological relations such as embodiment, alterity, and background, which shows how artefacts mediate our perception, structure our engagement with the world, and even recede into the background while shaping our lived environment. Technologies are not mere tools but shape the very way in which we perceive, remember, and act in the world, whether through glasses, cameras, or canes. Extending this insight to scientific knowledge, Ihde proposes a "technological hermeneutics," arguing that science is not a disembodied cognitive act but a materially mediated practice. Technologies such as microscopes or telescopes do not simply extend human vision; they actively transform what becomes visible and thus what can be known. In this view, scientific knowledge is technologically constructed—embedded in instruments, shaped by mediation, and co-constituted through human-technology-world relations. This marks a paradigmatic shift away from viewing science as objective observation and towards an interpretive, hermeneutic engagement with a technologically structured reality.

## Self-Assessment

1. In what ways does Don Ihde's post-phenomenological approach differ from classical philosophical approaches to technology?
2. What is meant by the idea of technological mediation in Ihde's framework?
3. How do Ihde and Verbeek's analyses challenge the notion of technology as a neutral tool?
4. What role does human agency play in the post-phenomenological explanation of technology?

## Assignments

1. Compare and critically evaluate the approaches of Martin Heidegger and Don Ihde to the question of the essence and experience of technology.
2. Discuss the significance of technological mediation in shaping human perception and action, using examples from daily life.
3. Examine the implications of post-phenomenology for the ethical design of technology.
4. Reflect on how the post-phenomenological approach can be applied to emerging technologies such as AI or wearable tech.

## Reference


1. Ihde, D. (2002). Bodies in Technology. University of Minnesota Press.
2. Ihde, D. (1991). Instrumental Realism: The Interface Between Philosophy of Science and Philosophy of Technology. Indiana University Press.
3. Ihde, D. (2009). Post-phenomenology and Technoscience: The Peking University Lectures. SUNY Press.
4. Verbeek, P.-P. (2011). Moralizing Technology: Understanding and Designing the Morality of Things. University of Chicago Press.
5. Verbeek, P. P. C. C. (2001). Don Ihde: The Technological Lifeworld. In H. J. Achterhuis (Ed.), American Philosophy of Technology: The Empirical Turn (pp. 119–146). Indiana University Press.
6. Brey, P. (2000). Technology as Extension of Human Faculties. In C. Mitcham (Ed.), Metaphysics, Epistemology, and Technology (Research in Philosophy and Technology, Vol. 19, pp. 59–78). JAI Press.
7. Feenberg, A. (1999). Questioning Technology. Routledge.
8. Latour, B. (1987). Science in Action: How to Follow Scientists and Engineers Through Society. Harvard University Press.




## Suggested Reading


1. Ihde, D. (1990). *Technology and the Lifeworld: From Garden to Earth*. Indiana University Press.
2. Verbeek, P.-P. (2005). *What Things Do: Philosophical Reflections on Technology, Agency, and Design.* Penn State University Press.
3. Feenberg, A. (2002). *Transforming Technology: A Critical Theory Revisited*. Oxford University Press.
4. Selinger, E. (Ed.). (2006). *Post-phenomenology: A Critical Companion to Ihde*. SUNY Press.
5. Scharff, R. C., & Dusek, V. (Eds.). (2014). *Philosophy of Technology: The Technological Condition*(2nd ed.). Wiley-Blackwell.
6. Jonas, H. (1984). *The Imperative of Responsibility: In Search of an Ethics for the Technological Age.* University of Chicago Press.
7. P, Merleau. (1962) *Phenomenology of Perception*, trans. Colin Smith. London: Routledge.

## Space for Learner Engagement for Objective Questions

Learners are encouraged to develop objective questions based on the content in the paragraph as a sign of their comprehension of the content. The Learners may reflect on the recap bullets and relate their understanding with the narrative in order to frame objective questions from the given text. The University expects that 1 - 2 questions are developed for each paragraph. The space given below can be used for listing the questions.

# UNIT 4
# Is Technology (Value) Neutral?

## Learning Outcomes

By the end of this unit, the learner will be able to:

- explain the classical notion of value-neutrality in science and technology and its basis in the fact-value dichotomy
- critically assess the challenges to value-neutrality posed by theory-ladenness and value-ladenness in scientific and technological practices
- compare and contrast key philosophical positions such as instrumentalism, substantivism, and critical theory regarding technological neutrality
- analyse the role of values in the design, use, and impact of technological artefacts
- evaluate how technological mediation shapes human experiences and moral decisions



## Background

Is technology morally and politically neutral? The assumption that science and technology are value-neutral is based on the fact–value dichotomy, which separates objective knowledge (facts) from normative judgments (values). Science was understood to uncover truths about the natural world without moral or political interference, while ethics dealt with questions of what ought to be. However, developments in the philosophy of science have substantially eroded this divide. Thinkers like Thomas Kuhn and Hilary Putnam have shown that observation itself is theory-laden and that epistemic values such as coherence and simplicity shape scientific theory choice. These insights challenge the idea of scientific objectivity and suggest that even the "facts" of science are infused with human values and assumptions.

This shift in explanation has profound implications for our view of technology. If science is not value-free, then the technologies that materialise scientific knowledge cannot be neutral either. Technologies are not merely tools awaiting human direction; they shape how we perceive, act, and relate to one another and the world. Philosophers such as Don Ihde, Andrew Feenberg, and Peter-Paul Verbeek argue that technologies mediate human experience and embody values within their design, structure, and use. These thinkers reject the classical instrumentalist view, which is still common in engineering and policy discourse, that technologies are neutral means to human ends. Instead, they demonstrate that values are embedded in the very logic and materiality of technological systems, influencing actions, shaping institutions, and co-constituting moral decisions.

## Keywords

Technology, Value neutrality, Theory-laden, Technological rationality, Political rationality

## Discussion

### 4.4.1 Science and Technology: Questioning Value-Neutrality

The traditional explanation of science has long been founded on the assumption of value-neutrality. This assumption is grounded in the idea of the fact-value dichotomy that treats science as a field concerned with objective truths (what is) distinct from normative concerns about what ought to be. For example, natural science is understood as the study of what exists in nature, not what ought to exist in nature. In contrast, ethics is concerned with evaluating human conduct/actions in terms of what ought to be. This distinction between descriptive (positive) and normative domains has been the foundation of how science is conceptualised in relation to values. However, this dichotomy has been deeply contested in recent decades.

- Traditional science was seen as value-neutral, separating facts (what is) from values (what ought to be)

In the previous block on the Philosophy of Science, we have already discussed in detail the theory-ladenness of observation and data, challenging the idea of 'pure observation' by scientists. It affirmed that whatever a scientist observes (data, facts, or phenomena) is shaped by the theoretical framework or background beliefs of the observer. Samir Okasha (2002) argues that the theory-ladenness of data forces us to abandon the concept of objective truth: "For to be objectively true, our theories or beliefs must correspond to the facts, but the idea of such a correspondence makes little sense if the facts themselves are infected by our theories. This is why Kuhn was led to the radical view that truth itself is relative to a paradigm."

- Scientific observations are shaped by prior theories; challenge to the notion of objective truth

- Putnam rejects strict objectivity and argues that truth and reason are jointly shaped by mind and world

In *Reason, Truth and History* (1982), Hilary Putnam challenges a number of philosophical dichotomies, particularly the one between 'objective and subjective views of truth and reason.' He critiques both the traditional correspondence theory of truth and the relativistic tendencies found in the works of Kuhn, Feyerabend, and Foucault, famously arguing that "the mind and the world jointly make up the mind and the world." Scientific inquiry, according to Putnam, is never pursued in a vacuum; rather, scientists seek truths that are meaningful, useful, and valuable within specific human contexts.

- Science is value-laden, with epistemic values shaping what counts as a fact

Coming to the value-ladenness of scientific facts and practice, Putnam (1982) strongly asserts, "science presupposes epistemic values," such as rational acceptability, justification, consistency, and functional simplicity. These epistemic values play a crucial role in the establishment of 'scientific facts.' In other words, judgments about what counts as a fact are guided by normative criteria, such as simplicity, coherence, and explanatory power. Putnam states: "The two cases, the case of ethics and the case of the philosophy of science, are moreover not unrelated; for, as I remarked earlier, hypothesis selection in science presupposes epistemic values, and the terms for these values – 'coherent,' 'simple,' 'beautiful' (applied to a theory), and the like – behave just like the 'thick ethical terms.'" In short, both theory-ladenness (all observations and data are 'laden' with theory) and value-ladenness (all scientific enquiries/facts are 'laden' with values) challenge the traditional view of science as value-neutral and objective.

- If science is value-laden, technology too embeds and mediates values

This growing recognition of science as a value-laden practice opens the door to a similar rethinking of technology. If science itself is not isolated from human contexts, presuppositions, frameworks, and values, how can technology, which is the material and instrumental expression of scientific knowledge, claim value-neutrality? Technology does not merely apply knowledge; it actively shapes human cognition, perception, behaviour, environments, relationships, and social structures. As Don Ihde and other post-phenomenologists argue, technologies mediate and transform how we experience and engage with the world. Just as the epistemic frameworks of science are increasingly seen to entangle with human commitments and social contexts, the development, design, and deployment of technologies must be analysed in light of the values they embed, mediate, and propagate. The claim of value-neutrality in technology thus appears increasingly untenable, especially in a world where technologies are deeply entangled with ethics, politics, and culture. This shift in explanation compels a critical look at the classical belief in technological neutrality that dominated earlier scientific and engineering discourse.

## 4.4.2 The Classical Assumption of Neutrality

- Morality resides only in users not in tools

The assumption that technology is neutral, that it merely provides tools for human use with no inherent moral or political character, has long underpinned modern scientific and engineering thinking. Rooted in Enlightenment rationalism and mechanistic metaphysics, this instrumentalist idea of technology separates means from ends, asserting that technologies are value-free mechanisms whose consequences depend solely on human intention. This notion is captured in slogans like "guns don't kill people, people kill people," a popular expression of the belief that morality resides only in users, not in tools. During the rise of industrial modernity, when progress was equated with mastery and efficiency, this perspective gained dominance.

- Classically, technology was seen as neutral tools, with morality residing only in users

However, this classical view has faced growing philosophical scrutiny. Scholars in the philosophy of technology, political theory, STS (Science and Technology Studies), and ethics argue that technologies are not neutral artefacts but actively mediate and reconfigure human experiences, actions, and social relations. We have already discussed Ihde's concept of 'technological hermeneutics' or the idea that science is not simply aided by technology; rather, it is materially constituted through it and 'laden' with technology. Ihde thereby analyses human-technology relations and inquires into the 'relations between technological artefacts and culture.' These analyses would undoubtedly prevent us from viewing technologies as value-neutral.

- For critical theorists, technology is never neutral; its design embeds social values and power; technological rationality is inherently political

In *Transforming Technology: A Critical Theory Revisited* (2002), Feenberg shows how critical theorists like Herbert Marcuse reject the neutrality of technology and argue instead that "technological rationality has become political rationality." By citing the 'political rationality' of technologies developed by critical theorists, Feenberg argues: "The values of a specific social system and the interests of its ruling classes are installed in the very design of rational procedures and machines even before these are assigned specific goals. The dominant form of technological rationality is neither an ideology (a discursive expression of class interest) nor a neutral reflection of natural laws. Rather, it stands at the intersection between ideology and technique where the two come together to control human beings and resources in conformity with what I will call 'technical codes.' Critical theory shows how these codes invisibly sediment values and interests in rules and procedures, devices and artefacts that routinise the pursuit of power and advantage by a dominant hegemony."

- Technology is socially shaped and contested, not neutral or predetermined

Feenberg further develops his position by emphasising that technology should not be understood as a fixed object but rather as an "ambivalent" process open to multiple developmental paths. Unlike the neutrality thesis, which sees values as influencing only the use of technology, the critical theory perspective insists that social values shape the very design of technical systems. In this view, technology is not a predetermined destiny but a contested domain shaped by competing visions and interests. As Feenberg (2002) writes, "technology is not a destiny but a scene of struggle. It is a social battlefield, or perhaps a better metaphor would be a 'parliament of things' in which civilisational alternatives contend," as Latour says. This framing reclaims agency and opens up possibilities for democratic interventions in technological development.

- Critical theory's middle ground; technology as both controllable and inherently value-laden

According to Feenberg, the critical theory of technology occupies a middle ground between instrumentalism and substantivism. It acknowledges, like instrumentalism, that technology is, in some sense, controllable, while also agreeing with substantivism that technology is inherently value-laden. At first glance, this may appear paradoxical, since substantivists typically claim that the values embedded in technology, such as efficiency and control, are intrinsic and thus beyond human influence. As Feenberg (2002) puts it, "It (critical theory) agrees with instrumentalism that technology is, in some sense, controllable, and it agrees with substantivism that technology is also value-laden. This seems a paradoxical position since precisely what cannot be controlled in the substantivist view are the values embodied in technology." He elaborates that in the substantivist framework, these values are not contingent or optional but rather essential features of any technical system, shaping human engagement with the world in terms of maximisation and control.

Similarly, Ihde (1990) in *Technology and the Lifeworld* critiques the neutrality thesis by demonstrating certain features that technology in use implies for human experience. He demands a fundamental rethinking of the simplistic separation between tool and user and affirms that the relationship between

- Technology's use is never neutral; there is a transformation of human experience in the use of technology

user and tool cannot be reduced to neutrality; it is transformative, perceptual, and inevitably value-laden. He states: "My thesis is that any use of technology is non-neutral. However, non-neutrality is not a prejudicial term because it implies neither that there are inherently 'good' or 'bad' tendencies so much as it implies that there are types of transformation of human experience in the use of technology."

## 4.4.3 Technological Artefacts and Moral Mediation

- Technology is not only value-laden but also socially and politically negotiable

The debate over value neutrality can be mapped along two axes: one concerning values (neutral vs. laden) and the other concerning agency (autonomous vs. controllable). Instrumentalists argue that technology is value-neutral and under human control. Substantivists like Jacques Ellul and Martin Heidegger, by contrast, suggest that technology is both autonomous and value-laden. Heidegger (1977) takes a further step by warning against the "enframing" of the world through modern technology, which reduces being to a resource. Feenberg takes a different stand and observes that technologies are value-laden but also socially constructed and politically negotiable.

- Computer systems inevitably embed the values of their designers; values are embedded in the production and design of technology

In practice, this debate comes alive in engineering and design. Nissenbaum (2001), in her article "How Computer Systems Embody Values," discusses how even supposedly neutral design choices inevitably reflect social, moral, and political values. She shows how computer system designers inevitably 'embody their values' in systems even when they are not consciously attempting to do so. This means that values are embedded in computer system design, whether or not designers intend them to be. The field of design ethics increasingly identifies that even minor technical decisions can produce substantial normative effects. Interface layouts, accessibility features, and data architecture can all influence behaviour, inclusion, and autonomy.

- Technologies are not silent 'intermediaries' but active 'mediators.'

Verbeek (2011) in *Moralizing Technology* extends these insights by expanding the concept of 'intentionality' to the field of technology. By using 'technological intentionality,' he argues that technologies are not morally neutral intermediaries but actively shape ethical contexts. As he puts it: "The central idea (of the technological mediation of morality) is that technologies-in-use help to establish relations between human beings and their environment. In these relations, technologies are not merely silent 'intermediaries' but active 'mediators' … By organising relations between humans and the world, technologies play an active, though not a final, role in morality. Technologies are morally charged, so to speak. They embody a material form of morality, and when used, the coupling of this 'material morality' and human moral agency results in a 'composite' moral agency."

- Technologies create/shape the framework within which we determine what we ought to do

His point is that rather than merely guiding what actions we undertake, technologies shape the framework within which we determine what we ought to do. Verbeek's proposal flips the neutrality assumption; that is, value-ladenness becomes an empirical claim, not a mere philosophical possibility. To illustrate the point, he discusses how tools might alter moral agency not by replacing it, but by co-shaping decision-making processes. This approach deepens ethical inquiry from abstract theory to examining how artefacts mediate moral experiences, making moral reflection on the design and deployment of technology critical.

## Summarized Overview

The traditional belief in the value-neutrality of technology is no longer tenable in light of philosophical and empirical evidence showing that technologies are active mediators of human experience and morality. Instrumentalist accounts overlook how values are embedded not just in the use of technologies but in their very design and development. Substantivist positions, such as Heidegger's and Ellul's, go too far in assuming that these values are beyond human control. Critical theorists like Feenberg offer a compelling middle path, arguing that technology is both value-laden and socially constructed, making it a site of political struggle and ethical negotiation. Similarly, Verbeek's concept of "technological intentionality" demonstrates how technologies co-shape moral reasoning by framing the choices and actions available to us. Therefore, to explain and design technologies responsibly, we must reject neutrality myths and acknowledge that technologies are saturated with values that demand critical reflection, contestation, and democratic deliberation.

## Self-Assessment

1. Explain the difference between value-ladenness in science and value-ladenness in technology.
2. Do you think that designers and engineers should be held morally responsible for how their technologies are used? Why or why not?
3. In what ways does Verbeek's theory of technological mediation shift the focus of ethical responsibility from users to artefacts?

## Assignments

1. Critically examine Feenberg's idea that technology is a "scene of struggle" rather than a destiny. How does this reframe debates on value-neutrality?
2. Compare and contrast instrumentalist and substantivist views of technology. Whose perspective is more compelling in today's digital society?
3. Using examples, explain how computer systems or interfaces can embody moral and political values, as argued by Nissenbaum.
4. Discuss the significance of Don Ihde's claim that "any use of technology is non-neutral." What implications does this have for design ethics?
5. Evaluate Peter-Paul Verbeek's concept of 'technological intentionality.' How does it challenge traditional ethical theories focused on human agents alone?

## Reference


1. Putnam, H. (1982). *Reason, Truth and History*. Cambridge University Press.
2. Putnam, H. (2002). *The Collapse of the Fact/Value Dichotomy and Other Essays*. Harvard University Press.
3. Winner, L. (1980). Do Artifacts Have Politics? *Daedalus*, 109(1), 121–136.
4. Verbeek, P.-P. (2011). *Moralizing Technology: Understanding and Designing the Morality of Things*. University of Chicago Press.
5. Feenberg, A. (2002). *Transforming Technology: A Critical Theory Revisited*. Oxford University Press.
6. Heidegger, M. (1977). *The Question Concerning Technology* (W. Lovitt, Trans.). Harper & Row.
7. Ihde, D. (1990). *Technology and the Lifeworld: From Garden to Earth*. Indiana University Press.
8. Okasha, S. (2002). *Philosophy of Science: A Very Short Introduction*. Oxford University Press.

## Suggested Reading


1. Latour, B. (1993). *We Have Never Been Modern* (C. Porter, Trans.). Harvard University Press.
2. Nissenbaum, H. (2001). *How Computer Systems Embody Values*. Computers and Society, 31(3), 38–45.
3. Pinch, T. J., & Bijker, W. E. (1984). The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other. In W. E. Bijker, T. P. Hughes & T. J. Pinch (Eds.), *The Social Construction of Technological Systems* (pp. 17–50). MIT Press.
4. De Boer, B., & Zwier, J. (Eds.). (2020). *Phenomenology and Philosophy of Technology*. Springer.


### Space for Learner Engagement for Objective Questions

Learners are encouraged to develop objective questions based on the content in the paragraph as a sign of their comprehension of the content. The Learners may reflect on the recap bullets and relate their understanding with the narrative in order to frame objective questions from the given text. The University expects that 1 - 2 questions are developed for each paragraph. The space given below can be used for listing the questions.

# MODEL QUESTION PAPER SETS

## SREENARAYANAGURU OPEN UNIVERSITY

**QP CODE: ………** **Reg. No : ....................**

**Name : ……..............**

**FOURTH SEMESTER - MA PHILOSOPHY EXAMINATION**

**DISCIPLINE CORE - M23PH11DC - Philosophy of Science**

**(CBCS - PG)**

**MODEL QUESTION PAPER- SET- I**

**2023 -24 Admission Onwards**

**Time: 3 Hours** **Max Marks: 70**

### SECTION A

**Answer any ten of the following. Each question carries one mark**

**(10X1 = 10 Marks)**

1. Who is the philosopher who introduced the concept of 'paradigm shift' in the philosophy of science?
2. Who is the scientist who imagined the cosmos as a great machine operating according to fixed laws, which could be described with precision and certainty?
3. Name the scientific theory which states that science reveals the objective reality of both seen and unseen entities.
4. What is explanans?
5. Science should begin with the careful observation of nature – which theory upheld this view?
6. Who said that to practice true science we must first overcome the idols?
7. Goodman's puzzle about projectible predicates in inductive reasoning is called …?
8. Name the scientific method which states that genuine knowledge comes from experience, observation, and logical reasoning.
9. Science functions within a shared framework maintained by a scientific community. What is the phrase which Kuhn used to explain this view?
10. Who is the author of *What is This Thing Called Science*?

11. Who introduced science without method?
12. What is the core point of feminist epistemology?
13. What is the meaning of techne in ancient Greek?
14. "Art imitates nature" – who said this?
15. What is the instrumental theory of technology?

**SECTION B**

**Answer any five questions in two or three sentences each. Each question carries two marks.**

**(5X2 =10 Marks)**

16. Elaborate the problem of induction.
17. Scientific theories are not derived from observations, but rather are imaginative guesses or hypotheses created by scientists. These hypotheses are then tested through observations and experiments. Explain this method of science.
18. Elaborate the meaning of epistemological and methodological anarchy in Feyerabend.
19. Science aims to discover truths about natural world which exists independently of human perceptions. What is this theory known as? Explain.
20. The essence of technology is of technological - who upheld this view and what does it mean?
21. Explain scientific anti-realism.
22. Explain under-determination in science.
23. What is Don Ihde's post-phenomenological turn in philosophy of technology about?
24. Describe Don Ihden's concept 'technological lifeworld'.
25. Explain the meaning of term 'verisimilitude' developed by Karl Popper to explain how science progresses.

**SECTION C**

**Answer any five questions in a paragraph. Each question carries four marks.**

**(5X4 = 20 Marks)**

26. Lakatos described the development of science as a kind of 'war of attrition'.
27. Discuss minimum two contrasting views on the progress of science.

28. Elaborate Kuhn's structure of scientific development: Pre-science — normal science — crisis — revolution — new normal science — new crisis.

29. Compare and contrast methods of verificationism and falsificationism.

30. Explain the key difference between post-phenomenological theories of technology and Heidegger's philosophy of technology.

31. Scientific realism trusts unobservable entities as real because they help science succeed – Elaborate.

32. Elaborate the four essential conditions for an explanation to qualify as scientific under the Deductive-Nomological model.

33. Elaborate Law of Uniformity of Nature.

## SECTION D

**Answer any three questions in two pages. Each question carries ten marks.**

**( 3X10 =30 Marks)**

34. What is the role of explanations in science? Explain any two models of scientific explanation in detail.

35. Science is not linear and cumulative process. Explain Kuhn's views including his criticism of the enlightenment view of science in detail.

36. Discuss Paul Feyerabend's critique of scientific rationality in Against Method. How does his slogan "anything goes" challenge traditional philosophies of science such as those of Popper and Kuhn?

37. What is philosophy of technology, and why does it matter? Explain key debates in philosophy of technology.

38. How do debates among Positivism, Logical Positivism, Karl Popper, and the Vienna Circle illuminate the problem of demarcation between science and non-science? Discuss with suitable examples.

39. Critically analyze Lakatos's methodology of Scientific Research Programmes and his view about progress of science.

# SREENARAYANAGURU OPEN UNIVERSITY

**QP CODE: ………** **Reg. No : ....................**

**Name : ……...........**

**FOURTH SEMESTER - MA PHILOSOPHY EXAMINATION**

**DISCIPLINE CORE - M23PH11DC - Philosophy of Science**

**(CBCS - PG)**

**MODEL QUESTION PAPER- SET- II**

**2023 -24 Admission Onwards**

**Time: 3 Hours** **Max Marks: 70**

---

## SECTION A

**Answer any ten of the following. Each question carries one mark**

**(10X1 = 10 Marks)**

1. What is incommensurability principle or the limits of rational comparison?
2. No amount of supporting evidence proves a theory, but one counterexample can falsify it. Who holds this view?
3. What is a hypothesis in science?
4. What is theory falsificationism in science?
5. Paradigm shift occurs due to persistent anomalies – which philosopher said this?
6. Who is the author of the book *The Question Concerning Technology?*
7. What is the meaning of value-neutrality of technology?
8. What is meaning of 'technological life-world' for Ihde?
9. What is the theory-ladenness of observation?
10. What is the ready-to-hand of use of technology according to Heidegger?
11. Who introduced the concept of the "Four Idols" and argued that overcoming them is necessary for proper scientific inquiry?
12. Who argued that there is no rational justification for believing that the future will always resemble the past (problem of induction)?
13. What is the positivist view in science?
14. Who is the author of who is the author of the book *The Poverty of Historicism*?
15. Which school of thought propounded verificationism?

## SECTION B

**Answer any five questions in two or three sentences each. Each question carries two marks.**

**(5X2 =10 Marks)**

16. Elaborate the debate on fact-value dichotomy in philosophy of science
17. Science dominates not by merit but because other knowledge systems have been systematically excluded. Whose argument is this? Explain.
18. Explain the demarcation problem in science.
19. What is Goodman's New Riddle of Induction? Elaborate
20. Explain the inductive leap/problem of induction.
21. What is the difference between verificationism and falsificationism?
22. Explain the methodology of Scientific Research Programmes.
23. What does Feyerabend say about the democratization and humanism of science in the book Science in a Free Society?
24. Explain the difference between normal science and scientific revolution according to Thomas Kuhn.
25. The claim that one scientific framework is not more 'true' than another is associated with which theory?



## SECTION C

**Answer any five questions in a paragraph. Each question carries four marks.**

**(5X4 = 20 Marks)**

26. Law of Universal Causation and Law of Uniformity of Nature are the key two postulates that act as the foundational beliefs that make induction possible. Elaborate.
27. Elaborate Lakatos's view of scientific progress.
28. What is the revolutionary argument Kuhn presents in his famous book The Structure of Scientific Revolutions?
29. Discuss the relation between philosophy and science.
30. Elaborate 'technological hermeneutics' developed by Ihde.
31. Critically examine Feyerabend's claim in *Against Method* that the scientific method is neither unique nor rational.
32. What is science and how does the philosophy of science differ from it? Explain how the philosophy of science explores the foundations, methods, and goals of scientific inquiry.

33. Paul Verbeek interprets Ihde's point: "Perception is as it were the interweaving of both: in perception, human beings and world - or subject and object for that matter - are not separated but always intertwined. Only afterward, when a perception is described and not enacted, does it make sense to separate out a perceiver and a perceived, or a subject and an object, as one says. In the perceiving itself that cannot be done, since to perceive is to perceive the world. In experiencing, people are as much 'in' the world as the world is 'in' them: they cannot be separated." Elaborate.

34. Evaluate Al-Farabi's political philosophy with reference to his concept of happiness.

## SECTION D

**Answer any three questions in two pages. Each question carries ten marks.**

**( 3X10 =30 Marks)**

34. "Anything goes". Explain Feyerabend's argument about the method of science and apply the same to a contemporary scientific or technological controversy (climate change, AI ethics, alternative medicine). Does Feyerabend's epistemological anarchism provide a productive way to evaluate such debates, or does it risk undermining scientific credibility?

35. Elucidate key thinkers and their ideas in phenomenology of technology.

36. "Is technology value-neutral? Critically examine this question by engaging with the fact–value dichotomy, theory-ladenness, and value-ladenness in science, and extend the discussion to technology through the perspectives of instrumentalism, substantivism, and critical theory?

37. Compare and contrast the theories of technology (instrumentalism, substantivism, and critical theory of technology). Name major philosophers and their arguments. Take a critical examination of the same.

38. Verificationism seeks to establish meaning through confirmation, while Falsificationism emphasizes testability through potential refutation. Critically analyze this distinction. Which approach offers a stronger demarcation between science and non-science, and why?

39. Compare and contrast scientific realism and scientific anti-realism. How does each position interpret the aim of science, particularly with respect to observable and unobservable entities?

**സർവ്വകലാശാലാഗീതം**

---------------------

വിദ്യയാൽ സ്വതന്ത്രരാകണം
വിശ്വപൗരരായി മാറണം
ഗ്രഹപ്രസാദമായ് വിളങ്ങണം
ഗുരുപ്രകാശമേ നയിക്കണേ

കൂരിരുട്ടിൽ നിന്നു ഞങ്ങളെ
സൂര്യവീഥിയിൽ തെളിക്കണം
സ്നേഹദീപ്തിയായ് വിളങ്ങണം
നീതിവൈജയന്തി പാറണം

ശാസ്ത്രവ്യാപ്തിയെന്നുമേകണം
ജാതിഭേദമാകെ മാറണം
ബോധരശ്മിയിൽ തിളങ്ങുവാൻ
ജ്ഞാനകേന്ദ്രമേ ജ്വലിക്കണേ

**കുരീപ്പുഴ ശ്രീകുമാർ**

# SREENARAYANAGURU OPEN UNIVERSITY



## Regional Centres


### Kozhikode
Govt. Arts and Science College
Meenchantha, Kozhikode,
Kerala, Pin: 673002
Ph: 04952920228
email: rckdirector@sgou.ac.in

### Thalassery
Govt. Brennen College
Dharmadam, Thalassery,
Kannur, Pin: 670106
Ph: 04902990494
email: rctdirector@sgou.ac.in

### Tripunithura
Govt. College
Tripunithura, Ernakulam,
Kerala, Pin: 682301
Ph: 04842927436
email: rcedirector@sgou.ac.in

### Pattambi
Sree Neelakanta Govt. Sanskrit College
Pattambi, Palakkad,
Kerala, Pin: 679303
Ph: 04662912009
email: rcpdirector@sgou.ac.in

# DON'T LET IT BE TOO LATE

# SAY NO TO DRUGS

## LOVE YOURSELF AND ALWAYS BE HEALTHY

SREENARAYANAGURU OPEN UNIVERSITY

**SREENARAYANAGURU OPEN UNIVERSITY**

The State University for Education, Training and Research in Blended Format, Kerala

# Philosophy of Science

COURSE CODE: M23PH11DC



Sreenarayanaguru Open University
Kollam, Kerala Pin- 691601, email: info@sgou.ac.in, www.sgou.ac.in Ph: +91 474 2966841

ISBN 978-81-990500-9-9
9 788199 050099