

= Philosophy of science =

Philosophy of science is a branch of philosophy concerned with the foundations , methods , and implications of science . The central questions of this study concern what qualifies as science , the reliability of scientific theories , and the ultimate purpose of science . This discipline overlaps with metaphysics , ontology , and epistemology , for example , when it explores the relationship between science and truth .

There is no consensus among philosophers about many of the central problems concerned with the philosophy of science , including whether science can reveal the truth about unobservable things and whether scientific reasoning can be justified at all . In addition to these general questions about science as a whole , philosophers of science consider problems that apply to particular sciences (such as biology or physics) . Some philosophers of science also use contemporary results in science to reach conclusions about philosophy itself .

While philosophical thought pertaining to science dates back at least to the time of Aristotle , philosophy of science emerged as a distinct discipline only in the middle of the 20th century in the wake of the logical positivism movement , which aimed to formulate criteria for ensuring all philosophical statements ' meaningfulness and objectively assessing them . Thomas Kuhn 's landmark 1962 book *The Structure of Scientific Revolutions* was also formative , challenging the view of scientific progress as steady , cumulative acquisition of knowledge based on a fixed method of systematic experimentation and instead arguing that any progress is relative to a " paradigm , " the set of questions , concepts , and practices that define a scientific discipline in a particular historical period .

Subsequently , the coherentist approach to science , in which a theory is validated if it makes sense of observations as part of a coherent whole , became prominent due to W. V. Quine and others . Some thinkers such as Stephen Jay Gould seek to ground science in axiomatic assumptions , such as the uniformity of nature . A vocal minority of philosophers , and Paul Feyerabend (1924 ? 1994) in particular , argue that there is no such thing as the " scientific method " , so all approaches to science should be allowed , including explicitly supernatural ones . Another approach to thinking about science involves studying how knowledge is created from a sociological perspective , an approach represented by scholars like David Bloor and Barry Barnes . Finally , a tradition in continental philosophy approaches science from the perspective of a rigorous analysis of human experience .

Philosophies of the particular sciences range from questions about the nature of time raised by Einstein 's general relativity , to the implications of economics for public policy . A central theme is whether one scientific discipline can be reduced to the terms of another . That is , can chemistry be reduced to physics , or can sociology be reduced to individual psychology ? The general questions of philosophy of science also arise with greater specificity in some particular sciences . For instance , the question of the validity of scientific reasoning is seen in a different guise in the foundations of statistics . The question of what counts as science and what should be excluded arises as a life @-@ or @-@ death matter in the philosophy of medicine . Additionally , the philosophies of biology , of psychology , and of the social sciences explore whether the scientific studies of human nature can achieve objectivity or are inevitably shaped by values and by social relations .

= = Introduction = =

= = = Defining science = = =

Distinguishing between science and non @-@ science is referred to as the demarcation problem . For example , should psychoanalysis be considered science ? How about so @-@ called creation science , the inflationary multiverse hypothesis , or macroeconomics ? Karl Popper called this the central question in the philosophy of science . However , no unified account of the problem has won acceptance among philosophers , and some regard the problem as unsolvable or uninteresting .

Martin Gardner has argued for the use of a Potter Stewart standard (" I know it when I see it ") for recognizing pseudoscience .

Early attempts by the logical positivists grounded science in observation while non @-@ science was non @-@ observational and hence meaningless . Popper argued that the central property of science is falsifiability . That is , every genuinely scientific claim is capable of being proven false , at least in principle .

An area of study or speculation that masquerades as science in an attempt to claim a legitimacy that it would not otherwise be able to achieve is referred to as pseudoscience , fringe science , or junk science . Physicist Richard Feynman coined the term " cargo cult science " for cases in which researchers believe they are doing science because their activities have the outward appearance of it but actually lack the " kind of utter honesty " that allows their results to be rigorously evaluated .

= = = Scientific explanation = = =

A closely related question is what counts as a good scientific explanation . In addition to providing predictions about future events , society often takes scientific theories to provide explanations for events that occur regularly or have already occurred . Philosophers have investigated the criteria by which a scientific theory can be said to have successfully explained a phenomenon , as well as what it means to say a scientific theory has explanatory power .

One early and influential theory of scientific explanation is the deductive @-@ nomological model . It says that a successful scientific explanation must deduce the occurrence of the phenomena in question from a scientific law . This view has been subjected to substantial criticism , resulting in several widely acknowledged counterexamples to the theory . It is especially challenging to characterize what is meant by an explanation when the thing to be explained cannot be deduced from any law because it is a matter of chance , or otherwise cannot be perfectly predicted from what is known . Wesley Salmon developed a model in which a good scientific explanation must be statistically relevant to the outcome to be explained . Others have argued that the key to a good explanation is unifying disparate phenomena or providing a causal mechanism .

= = = Justifying science = = =

Although it is often taken for granted , it is not at all clear how one can infer the validity of a general statement from a number of specific instances or infer the truth of a theory from a series of successful tests . For example , a chicken observes that each morning the farmer comes and gives it food , for hundreds of days in a row . The chicken may therefore use inductive reasoning to infer that the farmer will bring food every morning . However , one morning , the farmer comes and kills the chicken . How is scientific reasoning more trustworthy than the chicken 's reasoning ?

One approach is to acknowledge that induction cannot achieve certainty , but observing more instances of a general statement can at least make the general statement more probable . So the chicken would be right to conclude from all those mornings that it is likely the farmer will come with food again the next morning , even if it cannot be certain . However , there remain difficult questions about what precise probability any given evidence justifies putting on the general statement . One way out of these particular difficulties is to declare that all beliefs about scientific theories are subjective , or personal , and correct reasoning is merely about how evidence should change one 's subjective beliefs over time .

Some argue that what scientists do is not inductive reasoning at all but rather abductive reasoning , or inference to the best explanation . In this account , science is not about generalizing specific instances but rather about hypothesizing explanations for what is observed . As discussed in the previous section , it is not always clear what is meant by the " best explanation . " Ockham 's razor , which counsels choosing the simplest available explanation , thus plays an important role in some versions of this approach . To return to the example of the chicken , would it be simpler to suppose that the farmer cares about it and will continue taking care of it indefinitely or that the farmer is fattening it up for slaughter ? Philosophers have tried to make this heuristic principle more precise in

terms of theoretical parsimony or other measures . Yet , although various measures of simplicity have been brought forward as potential candidates , it is generally accepted that there is no such thing as a theory @-@ independent measure of simplicity . In other words , there appear to be as many different measures of simplicity as there are theories themselves , and the task of choosing between measures of simplicity appears to be every bit as problematic as the job of choosing between theories .

= = = Observation inseparable from theory = = =

When making observations , scientists look through telescopes , study images on electronic screens , record meter readings , and so on . Generally , on a basic level , they can agree on what they see , e.g. , the thermometer shows 37 @. @ 9 degrees C. But , if these scientists have different ideas about the theories that have been developed to explain these basic observations , they may disagree about what they are observing . For example , before Albert Einstein 's general theory of relativity , observers would have likely interpreted the image at left as five different objects in space . In light of that theory , however , astronomers will tell you that is actually only two objects , one in the center and four different images of the same object around the sides . Alternatively , if other scientists suspect that something is wrong with the telescope and only one object is actually being observed , they are operating under yet another theory . Observations that cannot be separated from theoretical interpretation are said to be theory @-@ laden .

All observation involves both perception and cognition . That is , one does not make an observation passively , but rather is actively engaged in distinguishing the phenomenon being observed from surrounding sensory data . Therefore , observations are affected by one 's underlying understanding of the way in which the world functions , and that understanding may influence what is perceived , noticed , or deemed worthy of consideration . In this sense , it can be argued that all observation is theory @-@ laden .

= = = The purpose of science = = =

Should science aim to determine ultimate truth , or are there questions that science cannot answer ? Scientific realists claim that science aims at truth and that one ought to regard scientific theories as true , approximately true , or likely true . Conversely , scientific anti @-@ realists argue that science does not aim (or at least does not succeed) at truth , especially truth about unobservables like electrons or other universes . Instrumentalists argue that scientific theories should only be evaluated on whether they are useful . In their view , whether theories are true or not is beside the point , because the purpose of science is to make predictions and enable effective technology .

Realists often point to the success of recent scientific theories as evidence for the truth (or near truth) of current theories . Antirealists point to either the many false theories in the history of science , epistemic morals , the success of false modeling assumptions , or widely termed postmodern criticisms of objectivity as evidence against scientific realism . Antirealists attempt to explain the success of scientific theories without reference to truth . Some antirealists claim that scientific theories aim at being accurate only about observable objects and argue that their success is primarily judged by that criterion .

= = = Values and science = = =

Values intersect with science in different ways . There are epistemic values that mainly guide the scientific research . The scientific enterprise is embedded in particular culture and values through individual practitioners . Values emerge from science , both as product and process and can be distributed among several cultures in the society .

If it is unclear what counts as science , how the process of confirming theories works , and what the purpose of science is , there is considerable scope for values and other social influences to shape science . Indeed , values can play a role ranging from determining which research gets funded to

influencing which theories achieve scientific consensus . For example , in the 19th century , cultural values held by scientists about race shaped research on evolution , and values concerning social class influenced debates on phrenology (considered scientific at the time) . Feminist philosophers of science , sociologists of science , and others explore how social values affect science .

= = History = =

= = = Pre @-@ modern = = =

The origins of philosophy of science trace back to Plato and Aristotle who distinguished the forms of approximate and exact reasoning , set out the threefold scheme of abductive , deductive , and inductive inference , and also analyzed reasoning by analogy . The eleventh century Arab polymath Ibn al @-@ Haytham (known in Latin as Alhazen) conducted his research in optics by way of controlled experimental testing and applied geometry , especially in his investigations into the images resulting from the reflection and refraction of light . Roger Bacon (1214 ? 1294) , an English thinker and experimenter heavily influenced by al @-@ Haytham , is recognized by many to be the father of modern scientific method . His view that mathematics was essential to a correct understanding of natural philosophy was considered to be 400 years ahead of its time .

= = = Modern = = =

Francis Bacon (no direct relation to Roger , who lived 300 years earlier) was a seminal figure in philosophy of science at the time of the Scientific Revolution . In his work *Novum Organum* (1620) ? a reference to Aristotle 's *Organon* ? Bacon outlined a new system of logic to improve upon the old philosophical process of syllogism . Bacon 's method relied on experimental histories to eliminate alternative theories . In 1637 , René Descartes established a new framework for grounding scientific knowledge in his treatise , *Discourse on Method* , advocating the central role of reason as opposed to sensory experience . By contrast , in 1713 , the 2nd edition of Isaac Newton 's *Philosophiae Naturalis Principia Mathematica* argued that " ... hypotheses ... have no place in experimental philosophy . In this philosophy [,] propositions are deduced from the phenomena and rendered general by induction . " This passage influenced a " later generation of philosophically @-@ inclined readers to pronounce a ban on causal hypotheses in natural philosophy . " In particular , later in the 18th century , David Hume would famously articulate skepticism about the ability of science to determine causality and gave a definitive formulation of the problem of induction . The 19th century writings of John Stuart Mill are also considered important in the formation of current conceptions of the scientific method , as well as anticipating later accounts of scientific explanation .

= = = Logical positivism = = =

Instrumentalism became popular among physicists around the turn of the 20th century , after which logical positivism defined the field for several decades . Logical positivism accepts only testable statements as meaningful , rejects metaphysical interpretations , and embraces verificationism (a set of theories of knowledge that combines logicism , empiricism , and linguistics to ground philosophy on a basis consistent with examples from the empirical sciences) . Seeking to overhaul all of philosophy and convert it to a new scientific philosophy , the Berlin Circle and the Vienna Circle propounded logical positivism in the late 1920s .

Interpreting Ludwig Wittgenstein 's early philosophy of language , logical positivists identified a verifiability principle or criterion of cognitive meaningfulness . From Bertrand Russell 's logicism they sought reduction of mathematics to logic . They also embraced Russell 's logical atomism , Ernst Mach 's phenomenalism ? whereby the mind knows only actual or potential sensory experience , which is the content of all sciences , whether physics or psychology ? and Percy Bridgman 's operationalism . Thereby , only the verifiable was scientific and cognitively meaningful , whereas the

unverifiable was unscientific , cognitively meaningless " pseudostatements " ? metaphysical , emotive , or such ? not worthy of further review by philosophers , who were newly tasked to organize knowledge rather than develop new knowledge .

Logical positivism is commonly portrayed as taking the extreme position that scientific language should never refer to anything unobservable ? even the seemingly core notions of causality , mechanism , and principles ? but that is an exaggeration . Talk of such unobservables could be allowed as metaphorical ? direct observations viewed in the abstract ? or at worst metaphysical or emotional . Theoretical laws would be reduced to empirical laws , while theoretical terms would garner meaning from observational terms via correspondence rules . Mathematics in physics would reduce to symbolic logic via logicism , while rational reconstruction would convert ordinary language into standardized equivalents , all networked and united by a logical syntax . A scientific theory would be stated with its method of verification , whereby a logical calculus or empirical operation could verify its falsity or truth .

In the late 1930s , logical positivists fled Germany and Austria for Britain and America . By then , many had replaced Mach 's phenomenalism with Otto Neurath 's physicalism , and Rudolf Carnap had sought to replace verification with simply confirmation . With World War II 's close in 1945 , logical positivism became milder , logical empiricism , led largely by Carl Hempel , in America , who expounded the covering law model of scientific explanation as a way of identifying the logical form of explanations without any reference to the suspect notion of " causation " . The logical positivist movement became a major underpinning of analytic philosophy , and dominated Anglosphere philosophy , including philosophy of science , while influencing sciences , into the 1960s . Yet the movement failed to resolve its central problems , and its doctrines were increasingly assaulted . Nevertheless , it brought about the establishment of philosophy of science as a distinct subdiscipline of philosophy , with Carl Hempel playing a key role .

= = = Thomas Kuhn = = =

In his landmark 1962 book *The Structure of Scientific Revolutions* , Thomas Kuhn crystallized the reaction against logical positivism . He argued that the process of observation and evaluation takes place within a paradigm . By paradigm he meant a logically consistent " portrait " of the world that is consistent with observations made from its point of view . A paradigm also encompasses the set of questions and practices that define a scientific discipline . He characterized normal science as the process of observation and " puzzle solving " which takes place within a paradigm , whereas revolutionary science occurs when one paradigm overtakes another in a paradigm shift .

Kuhn denied that it is ever possible to isolate the hypothesis being tested from the influence of the theory in which the observations are grounded , and he argued that it is not possible to evaluate competing paradigms independently . More than one logically consistent construct can paint a usable likeness of the world , but there is no common ground from which to pit two against each other , theory against theory . Each paradigm has its own distinct questions , aims , and interpretations . Neither provides a standard by which the other can be judged , so there is no clear way to measure scientific progress across paradigms .

For Kuhn , the choice of paradigm was sustained by rational processes , but not ultimately determined by them . The choice between paradigms involves setting two or more " portraits " against the world and deciding which likeness is most promising . For Kuhn , acceptance or rejection of a paradigm is a social process as much as a logical process . Kuhn 's position , however , is not one of relativism . According to Kuhn , a paradigm shift occurs when a significant number of observational anomalies arise in the old paradigm and a new paradigm makes sense of them . That is , the choice of a new paradigm is based on observations , even though those observations are made against the background of the old paradigm .

= = Current approaches = =

= = = Axiomatic assumptions = = =

Some thinkers seek to articulate axiomatic assumptions on which science may be based , a form of foundationalism . This is typically the implicit philosophy of working scientists , that the following basic assumptions that are needed to justify the scientific method : (1) that there is an objective reality shared by all rational observers ; (2) that this objective reality is governed by natural laws ; (3) that these laws can be discovered by means of systematic observation and experimentation . Proponents argue that these assumptions are reasonable and necessary for practicing science . For instance , Hugh Gauch argues that science presupposes that " the physical world is orderly and comprehensible . " Likewise , biologist Stephen Jay Gould cites the constancy of nature 's laws as an assumption which a scientist should assume before proceeding to do geology . In this view , the uniformity of scientific laws is an unprovable postulate which enables scientists to extrapolate into the unobservable past . In other words , the constancy of natural laws must be assumed in order to meaningfully study the past .

= = = Coherentism = = =

In contrast to the view that science rests on foundational assumptions , coherentism asserts that statements are justified by being a part of a coherent system . Or , rather , individual statements cannot be validated on their own : only coherent systems can be justified . A prediction of a transit of Venus is justified by its being coherent with broader beliefs about celestial mechanics and earlier observations . As explained above , observation is a cognitive act . That is , it relies on a pre @-@ existing understanding , a systematic set of beliefs . An observation of a transit of Venus requires a huge range of auxiliary beliefs , such as those that describe the optics of telescopes , the mechanics of the telescope mount , and an understanding of celestial mechanics . If the prediction fails and a transit is not observed , that is likely to occasion an adjustment in the system , a change in some auxiliary assumption , rather than a rejection of the theoretical system .

In fact , according to the Duhem ? Quine thesis , after Pierre Duhem and W. V. Quine , it is impossible to test a theory in isolation . One must always add auxiliary hypotheses in order to make testable predictions . For example , to test Newton 's Law of Gravitation in the solar system , one needs information about the masses and positions of the Sun and all the planets . Famously , the failure to predict the orbit of Uranus in the 19th century led not to the rejection of Newton 's Law but rather to the rejection of the hypothesis that the solar system comprises only seven planets . The investigations that followed led to the discovery of an eighth planet , Neptune . If a test fails , something is wrong . But there is a problem in figuring out what that something is : a missing planet , badly calibrated test equipment , an unsuspected curvature of space , or something else .

One consequence of the Duhem ? Quine thesis is that one can make any theory compatible with any empirical observation by the addition of a sufficient number of suitable ad hoc hypotheses . Karl Popper accepted this thesis , leading him to reject naïve falsification . Instead , he favored a " survival of the fittest " view in which the most falsifiable scientific theories are to be preferred .

= = = Anything goes = = =

Austrian philosopher of science Paul Feyerabend (1924 ? 1994) argued that no description of scientific method could possibly be broad enough to encompass all the approaches and methods used by scientists . He claimed there are no useful and exception @-@ free methodological rules governing the progress of science . Feyerabend objected to prescriptive scientific method on the grounds that any such method would stifle and cramp scientific progress . Feyerabend claimed that " the only principle that does not inhibit progress is : anything goes " .

Feyerabend felt that science started as a liberating movement , but that over time it had become increasingly dogmatic and rigid , and therefore had become increasingly an ideology , and , despite its successes , science had started to attain some oppressive features . He argued it was not possible to come up with an unambiguous way to distinguish science from religion , magic , or

mythology . He saw the exclusive dominance of science as a means of directing society as authoritarian and ungrounded . Promulgation of this epistemological anarchism earned Feyerabend the title of " the worst enemy of science " from his detractors .

= = = Sociology of scientific knowledge = = =

According to Kuhn , science is an inherently communal activity which can only be done as part of a community . For him , the fundamental difference between science and other disciplines is the way in which the communities function . Others , especially Feyerabend and some post @-@ modernist thinkers , have argued that there is insufficient difference between social practices in science and other disciplines to maintain this distinction . For them , social factors play an important and direct role in scientific method , but they do not serve to differentiate science from other disciplines . On this account , science is socially constructed , though this does not necessarily imply the more radical notion that reality itself is a social construct .

However , some such as Quine do maintain that scientific reality is a social construct :

Physical objects are conceptually imported into the situation as convenient intermediaries not by definition in terms of experience , but simply as irreducible posits comparable , epistemologically , to the gods of Homer ... For my part I do , qua lay physicist , believe in physical objects and not in Homer 's gods ; and I consider it a scientific error to believe otherwise . But in point of epistemological footing , the physical objects and the gods differ only in degree and not in kind . Both sorts of entities enter our conceptions only as cultural posits .

The public backlash of scientists against such views , particularly in the 1990s , came to be known as the science wars .

A major development in recent decades has been the study of the formation , structure , and evolution of scientific communities by sociologists and anthropologists including David Bloor , Harry Collins , Bruno Latour , and Anselm Strauss . Concepts and methods (such as rational choice , social choice or game theory) from economics have also been applied for understanding the efficiency of scientific communities in the production of knowledge . This interdisciplinary field has come to be known as science and technology studies . Here the approach to the philosophy of science is to study how scientific communities actually operate .

= = = Continental philosophy = = =

Philosophers in the continental philosophical tradition are not traditionally categorized as philosophers of science . However , they have much to say about science , some of which has anticipated themes in the analytical tradition . For example , Nietzsche advanced the thesis in his " The Genealogy of Morals " that the motive for search of truth in sciences is a kind of ascetic ideal .

In general , science in continental philosophy is viewed from a world @-@ historical perspective . One of the first philosophers who supported this view was Georg Wilhelm Friedrich Hegel . Philosophers such as Pierre Duhem and Gaston Bachelard also wrote their works with this world @-@ historical approach to science , predating Kuhn by a generation or more . All of these approaches involve a historical and sociological turn to science , with a priority on lived experience (a kind of Husserlian " life @-@ world ") , rather than a progress @-@ based or anti @-@ historical approach as done in the analytic tradition . This emphasis can be traced through Edmund Husserl 's phenomenology , the late works of Merleau @-@ Ponty (Nature : Course Notes from the Collège de France , 1956 ? 1960) , and Martin Heidegger 's hermeneutics .

The largest effect on the continental tradition with respect to science was Martin Heidegger 's critique of the theoretical attitude in general which of course includes the scientific attitude . For this reason the continental tradition has remained much more skeptical of the importance of science in human life and philosophical inquiry . Nonetheless , there have been a number of important works : especially a Kuhnian precursor , Alexandre Koyré . Another important development was that of Foucault 's analysis of the historical and scientific thought in The Order of Things and his study of power and corruption within the " science " of madness . Post @-@ Heideggerian authors

contributing to the continental philosophy of science in the second half of the 20th century include Jürgen Habermas (e.g. , " Truth and Justification " , 1998) , Carl Friedrich von Weizsäcker (" The Unity of Nature " , 1980) , and Wolfgang Stegmüller (" Probleme und Resultate der Wissenschaftstheorie und Analytischen Philosophie " , 1973 ? 1986) .

= = Other topics = =

= = = Reductionism = = =

Analysis is the activity of breaking an observation or theory down into simpler concepts in order to understand it . Reductionism can refer to one of several philosophical positions related to this approach . One type of reductionism is the belief that all fields of study are ultimately amenable to scientific explanation . Perhaps a historical event might be explained in sociological and psychological terms , which in turn might be described in terms of human physiology , which in turn might be described in terms of chemistry and physics . Daniel Dennett distinguishes legitimate reductionism from what he calls greedy reductionism , which denies real complexities and leaps too quickly to sweeping generalizations .

= = = Social accountability = = =

A broad issue affecting the neutrality of science concerns the areas which science chooses to explore , that is , what part of the world and man is studied by science . Philip Kitcher in his " Science , Truth , and Democracy " argues that scientific studies that attempt to show one segment of the population as being less intelligent , successful or emotionally backward compared to others have a political feedback effect which further excludes such groups from access to science . Thus such studies undermine the broad consensus required for good science by excluding certain people , and so proving themselves in the end to be unscientific .

= = Philosophy of particular sciences = =

There is no such thing as philosophy @-@ free science ; there is only science whose philosophical baggage is taken on board without examination .

In addition to addressing the general questions regarding science and induction , many philosophers of science are occupied by investigating foundational problems in particular sciences . They also examine the implications of particular sciences for broader philosophical questions . The late 20th and early 21st century has seen a rise in the number of practitioners of philosophy of a particular science .

= = = Philosophy of statistics = = =

The problem of induction discussed above is seen in another form in debates over the foundations of statistics . The standard approach to statistical hypothesis testing avoids claims about whether evidence supports a hypothesis or makes it more probable . Instead , the typical test yields a p @-@ value , which is the probability of the evidence being such as it is , under the assumption that the hypothesis being tested is true . If the p @-@ value is too low , the hypothesis is rejected , in a way analogous to falsification . In contrast , Bayesian inference seeks to assign probabilities to hypotheses . Related topics in philosophy of statistics include probability interpretations , overfitting , and the difference between correlation and causation .

= = = Philosophy of mathematics = = =

Philosophy of mathematics is concerned with the philosophical foundations and implications of

mathematics . The central questions are whether numbers , triangles , and other mathematical entities exist independently of the human mind and what is the nature of mathematical propositions . Is asking whether " $1 + 1 = 2$ " is true fundamentally different from asking whether a ball is red ? Was calculus invented or discovered ? A related question is whether learning mathematics requires experience or reason alone . What does it mean to prove a mathematical theorem and how does one know whether a mathematical proof is correct ? Philosophers of mathematics also aim to clarify the relationships between mathematics and logic , human capabilities such as intuition , and the material universe .

== Philosophy of physics ==

Philosophy of physics is the study of the fundamental , philosophical questions underlying modern physics , the study of matter and energy and how they interact . The main questions concern the nature of space and time , atoms and atomism . Also included are the predictions of cosmology , the interpretation of quantum mechanics , the foundations of statistical mechanics , causality , determinism , and the nature of physical laws . Classically , several of these questions were studied as part of metaphysics (for example , those about causality , determinism , and space and time) .

== Philosophy of chemistry ==

Philosophy of chemistry is the philosophical study of the methodology and content of the science of chemistry . It is explored by philosophers , chemists , and philosopher @-@ chemist teams . It includes research on general philosophy of science issues as applied to chemistry . For example , can all chemical phenomena be explained by quantum mechanics or is it not possible to reduce chemistry to physics ? For another example , chemists have discussed the philosophy of how theories are confirmed in the context of confirming reaction mechanisms . Determining reaction mechanisms is difficult because they cannot be observed directly . Chemists can use a number of indirect measures as evidence to rule out certain mechanisms , but they are often unsure if the remaining mechanism is correct because there are many other possible mechanisms that they have not tested or even thought of . Philosophers have also sought to clarify the meaning of chemical concepts which do not refer to specific physical entities , such as chemical bonds .

== Philosophy of biology ==

Philosophy of biology deals with epistemological , metaphysical , and ethical issues in the biological and biomedical sciences . Although philosophers of science and philosophers generally have long been interested in biology (e.g. , Aristotle , Descartes , Leibniz and even Kant) , philosophy of biology only emerged as an independent field of philosophy in the 1960s and 1970s . Philosophers of science began to pay increasing attention to developments in biology , from the rise of the modern synthesis in the 1930s and 1940s to the discovery of the structure of deoxyribonucleic acid (DNA) in 1953 to more recent advances in genetic engineering . Other key ideas such as the reduction of all life processes to biochemical reactions as well as the incorporation of psychology into a broader neuroscience are also addressed . Research in current philosophy of biology includes investigation of the foundations of evolutionary theory , and the role of viruses as persistent symbionts in host genomes . As a consequence the evolution of genetic content order is seen as the result of competent genome editors in contrast to former narratives in which error replication events (mutations) dominated .

== Philosophy of medicine ==

Beyond medical ethics and bioethics , the philosophy of medicine is a branch of philosophy that includes the epistemology and ontology / metaphysics of medicine . Within the epistemology of medicine , evidence @-@ based medicine (EBM) (or evidence @-@ based practice (EBP)) has

attracted attention , most notably the roles of randomisation , blinding and placebo controls . Related to these areas of investigation , ontologies of specific interest to the philosophy of medicine include Cartesian dualism , the monogenetic conception of disease and the conceptualization of ' placebos ' and ' placebo effects ' . There is also a growing interest in the metaphysics of medicine , particularly the idea of causation . Philosophers of medicine might not only be interested in how medical knowledge is generated , but also in the nature of such phenomena . Causation is of interest because the purpose of much medical research is to establish causal relationships , e.g. what causes disease , or what causes people to get better .

= = = Philosophy of psychology = = =

Philosophy of psychology refers to issues at the theoretical foundations of modern psychology . Some of these issues are epistemological concerns about the methodology of psychological investigation . For example , is the best method for studying psychology to focus only on the response of behavior to external stimuli or should psychologists focus on mental perception and thought processes ? If the latter , an important question is how the internal experiences of others can be measured . Self @-@ reports of feelings and beliefs may not be reliable because , even in cases in which there is no apparent incentive for subjects to intentionally deceive in their answers , self @-@ deception or selective memory may affect their responses . Then even in the case of accurate self @-@ reports , how can responses be compared across individuals ? Even if two individuals respond with the same answer on a Likert scale , they may be experiencing very different things .

Other issues in philosophy of psychology are philosophical questions about the nature of mind , brain , and cognition , and are perhaps more commonly thought of as part of cognitive science , or philosophy of mind . For example , are humans rational creatures ? Is there any sense in which they have free will , and how does that relate to the experience of making choices ? Philosophy of psychology also closely monitors contemporary work conducted in cognitive neuroscience , evolutionary psychology , and artificial intelligence , questioning what they can and cannot explain in psychology .

Philosophy of psychology is a relatively young field , because psychology only became a discipline of its own in the late 1800s . In particular , neurophilosophy has just recently become its own field with the works of Paul Churchland and Patricia Churchland . Philosophy of mind , by contrast , has been a well @-@ established discipline since before psychology was a field of study at all . It is concerned with questions about the very nature of mind , the qualities of experience , and particular issues like the debate between dualism and monism . Another related field is philosophy of language .

= = = Philosophy of economics = = =

Philosophy of economics is the branch of philosophy which studies philosophical issues relating to economics . It can also be defined as the branch of economics which studies its own foundations and morality . It can be categorized into three central topics . The first concerns the definition and scope of economics and by what methods it should be studied and whether these methods rise to the level of epistemic reliability associated with the other special sciences . For example , is it possible to research economics in such a way that it is value @-@ free , establishing facts that are independent of the normative views of the researcher ? The second topic is the meaning and implications of rationality . For example , can buying lottery tickets (increasing the riskiness of your income) at the same time as buying insurance (decreasing the riskiness of your income) be rational ? The third topic is the normative evaluation of economic policies and outcomes . What criteria should be used to determine whether a given public policy is beneficial for society ?

= = = Philosophy of social science = = =

The philosophy of social science is the study of the logic and method of the social sciences , such as sociology , anthropology , and political science . Philosophers of social science are concerned with the differences and similarities between the social and the natural sciences , causal relationships between social phenomena , the possible existence of social laws , and the ontological significance of structure and agency .

The French philosopher , Auguste Comte (1798 ? 1857) , established the epistemological perspective of positivism in *The Course in Positivist Philosophy* , a series of texts published between 1830 and 1842 . The first three volumes of the *Course* dealt chiefly with the physical sciences already in existence (mathematics , astronomy , physics , chemistry , biology) , whereas the latter two emphasised the inevitable coming of social science : " sociologie " . For Comte , the physical sciences had necessarily to arrive first , before humanity could adequately channel its efforts into the most challenging and complex " Queen science " of human society itself . Comte offers an evolutionary system proposing that society undergoes three phases in its quest for the truth according to a general ' law of three stages ' . These are (1) the theological , (2) the metaphysical , and (3) the positive .

Comte 's positivism established the initial philosophical foundations for formal sociology and social research . Durkheim , Marx , and Weber are more typically cited as the fathers of contemporary social science . In psychology , a positivistic approach has historically been favoured in behaviourism . Positivism has also been espoused by ' technocrats ' who believe in the inevitability of social progress through science and technology .

The positivist perspective has been associated with ' scientism ' ; the view that the methods of the natural sciences may be applied to all areas of investigation , be it philosophical , social scientific , or otherwise . Among most social scientists and historians , orthodox positivism has long since lost popular support . Today , practitioners of both social and physical sciences instead take into account the distorting effect of observer bias and structural limitations . This scepticism has been facilitated by a general weakening of deductivist accounts of science by philosophers such as Thomas Kuhn , and new philosophical movements such as critical realism and neopragmatism . The philosopher @-@ sociologist Jürgen Habermas has critiqued pure instrumental rationality as meaning that scientific @-@ thinking becomes something akin to ideology itself .