John Locke's philosophy was one of the first to contain scepticism of the idea of 'necessary connection' between causes and effects, and specifically, scepticism about the ontological grounding of causes. Locke feared that the lack of human capacity to understand natural things beyond their empirical facets forced some limitations upon the search for causes as a way to certain knowledge. He argued that instead of talking about unobservable causes, and assuming the 'real existence' of these unobservable ontological causes, science would be better justified if it relied on 'sense-experience'.[38] Locke, then, laid down the first empiricist critique of classical metaphysical and Renaissance rationalist understandings of causation, although he did not develop this empiricism to a systematic rejection of these positions.[39]

George Berkeley took up Locke's incipient scepticism on causation. Berkeley also drew on the tradition of occasionalism, that is, the theory of causation that asserted that there are no causes in the world besides God as the efficient and total cause.[40] The outcome of this combination of intellectual backgrounds was the development of the scepticist ontologically 'empty' notion of cause. Berkeley argued that 'natural causes' have no real ontological status – nor do they have 'active power' in them. All causal power ultimately relates back to God. Because of his sceptical stance on worldly natural causes Berkeley came to argue that all earthly science does is observe the law-like occurrences in the world – without speculating on their metaphysical status ('reality').[41] This step is crucial in leading up to the sceptical empiricist philosophy of causation of David Hume.

David Hume and empiricist scepticism on causation

David Hume's solution to the problem of causation, or as he rephrases it, the problem of causal relation, is not only one of the most oft-quoted in modern philosophy; it is also, for our purposes, the most crucial one to understand, for it is this conception of causation that can be seen

[38] Wallace (1972b: 29).

[39] However, despite advancing empiricist ideas Locke did not dispense fully with the idea of causation or the notion of 'causal powers'. Behind his pessimism about humans finding out necessary causal connections, he seems to acknowledge that this does not mean that there are no real causes in the world (even if they are often beyond our understanding). Locke (1970: 335).

[40] Loeb (1981: 229–68).

[41] Wallace (1972b: 36–7).

to have fundamentally influenced philosophy of science since. Hume advanced the first radically sceptic empiricist philosophy of causation, directly challenging both metaphysically realist and philosophically rationalist stances on causation.[42] The main contribution of Hume's philosophy, it is commonly agreed, is that it aimed to extend to its logical conclusions the sceptical critique of knowledge that emerged in modern philosophy with Locke and Berkeley. The question that Hume was grappling with was 'how can we really say we know anything for certain?', or perhaps more precisely, 'given we cannot know anything for certain, how can we justify science and knowledge?'[43] For Hume the 'solution' to the problem of knowledge lay in recognising that all knowledge arises purely from experience. The bases of knowledge – and the limits of our knowledge – are defined by what our perceptions transmit to us.

Hume promised to draw 'no conclusions but where he is authorised by experience'.[44] Against the rationalist philosophers such as Descartes, Hume argued that our ideas are not innate within us but arise from experience. Experiential impressions precede our ideas, our ideas are causally dependent on our impressions.[45] Instead of inquiring into ideas, we should, he argued, inquire into what is 'behind' the ideas that we hold, that is, the impressions that precipitate these particular ideas. In his *Inquiry Concerning Human Understanding* Hume states: 'By bringing ideas in so clear a light we may reasonably hope to remove all dispute which may arise concerning their nature and reality.'[46] Against the philosophical realist premises of the 'antient' philosophers and many Renaissance scientists, Hume famously argued that it is impossible to conceptualise the nature of reality beyond our impressions: because we have no way of justifying knowledge beyond our impressions and (impression-derived) ideas. Any claim to knowledge beyond experience is simply meaningless, he argued. Hume, thus, initiated the radical empiricist critique of metaphysics according to

[42] The critiques of modern Sceptics are in many ways developed on the same lines as the ancient Greek scepticism of Pyrrhos and Aenesidemus. See Hankinson (1998: 269).

[43] There was then a positive not just a sceptical element to his thought too. See Norton (1993a: 1).

[44] Hume (1978: 646).

[45] In that they are regularly conjoined with ideas and precede them. Norton (1993a: 6).

[46] Hume (1955: 29).

which the human mind and perceptions take precedence over 'reality'. As a result, any claims concerning external objects outside perceptions were to be 'committed to the flames' as metaphysical.[47]

The human mind, for Hume, is 'nothing more than a faculty of compounding, transposing, augmenting or diminishing the materials afforded to us by senses and experience'.[48] Our 'associations between ideas', he argues, arise from three things: '*resemblance, contiguity* in time and place and *cause* and *effect*'.[49] Importantly, Hume is careful in defining the most important form of the 'associations between ideas', that is, the relation between cause and effect. Hume did not think it was possible to define causes on the basis of 'efficacy, agency, power, force, energy, necessity, connexion or productive quality' as many previous philosophers had assumed.[50] These definitions, Hume points out, are all 'metaphysical' (refer to what cannot be experienced) and, thus, cannot be used to define causation.[51]

Hume argues that 'instead of searching for the idea [of cause and effect] in these definitions' we must 'look for it in impressions, from which it originally derived'.[52] He argues that there is nothing that can be perceived about causal relation *per se* in terms of 'powers', 'energy' or 'necessity' between cause and effect.[53] What the idea of causal relation, and the belief in the 'necessary connection' between cause and effect, come down to is the experience of 'constant conjunctions' of observable impressions, which our mind through 'custom' comes to 'link' together. We talk of 'causes and effects', he argues, when we have perceived certain observables or events regularly following each other: when we observe billiard balls colliding in regular successions we come to assume that the movement of one ball is the cause of the movement of the other.

Hume argues that a cause should be defined as 'an object precedent and contiguous to another, and where all the objects resembling the former are plac'd in like relations of precedency and contiguity to those objects which resemble the latter'.[54] Causation, or causal relation between a cause and an effect, is but an 'illusion' created in our minds through habit and imagination when we have observed certain constant conjunctions of observables or events in regular succession.

[47] See, for example, Rosenberg (1993: 67–70). [48] Hume (1955: 27).
[49] Hume (1978: 11). [50] Hume (1978: 157). [51] Hume (1978: 77).
[52] Hume (1978: 157). [53] Hume (1978: 161–3). [54] Hume (1978: 170).

Upon the whole, *necessity is something that exists in the mind, not in objects*: nor is it possible for us ever to form the most distant idea of it considered as a quality of bodies. Either we have no idea of necessity, or *necessity is nothing but that determination of the thought to pass from causes to effects and from effects to causes, according to their experienced union.*[55]

Being simply an 'imagined' relation between successively observed events there are no metaphysical constraints on Humean causes: as long as regularities are present 'any thing may produce any thing'.[56] The one important qualification Hume insists on is that causes must be prior to their effects: indeed, in order to identify what is 'cause' and what an 'effect' Hume needs to define cause as the 'precedent event', that is, the type of event that is observed temporally prior to the effect.

This definition of cause is characterised by certain key assumptions – assumptions that will here be termed Humean assumptions. The guiding light of all these assumptions is the empiricist principle that all knowledge is derived from empirical experience.

First, Hume's definition of cause entails that all that can be said about causes must be derived from analysis of regular successions of perceptions: the idea of cause emerges in our heads only when we have observed certain types of events or occurrences in 'constant conjunctions'. Beyond regular successions of perceived events or occurrences there is no meaning to the notion of cause, and no basis for making claims about causal relations between causes and effects. Thus, the only way to find out what caused a billiard ball to move is to examine regular instances in which the billiard ball moved, for example, particular kinds of collisions between billiard balls.[57] These regular experiences provide us with the only valid grounds to make a 'causal statement' about the relations of the objects.

Second, Hume reduces causal relation to a relation between 'observables': since all we can know is what we observe, causal relations cannot but be regularity relations between observables, that is, relations of observable objects (billiard balls), or perhaps rather more specifically, relations of statements pertaining to observable 'events' (billiard balls colliding). It should be noted that this assumption of observability

[55] Hume (1978: 165–6). Italics added.
[56] Hume (1978: 173). [57] Hume (1978: 652).

entails that the objects Humean approaches talk about are 'ontologically flat', or 'atomistic', that is, they do not interest us beyond their observable facets. Since all we can know is what we observe, questions about the nature or constitution of objects beyond observability cannot be talked about meaningfully. For example, questions concerning the 'nature' and 'properties' of the billiard balls, let alone the 'powers' and 'capabilities' of the players, the table, or gravity, fall outside the limits of justifiable empiricist knowledge.

Third, the Humean definition denies the notion of 'natural necessity', that is, the idea that causes and effects are linked ontologically. Instead causal relations are characterised by another form of necessity: what is perhaps most accurately characterised as a psychological form of necesity, but has also been interpreted as close to a form of logical necessity. Hume tried to reduce the problem of causation to an epistemological issue, thus avoiding all ontological aspects of the problem of causation. He also avoided describing causal relations as in any way 'necessary'. However, it is difficult for him to avoid presuming some sort of necessary relation between causes and effects. For example, if we have observed billiard ball A hitting ball B for N amount of times, we have, on Humean grounds, a basis for saying A is the cause of B's movement. But what is the nature of this connection between A and B for Hume? It is, he argues, a connection derived from the psychological workings of the mind. However, interestingly, the form of psychological connection Hume describes is close to a form of logic, which is arguably why many followers of Hume have come to talk about the causal relations between regularly conjoined types of events as 'logically necessary'. There seems to be confusion between logical and psychological forms of necessitation in the Humean account, although it is not clear whether this is Hume's confusion or his followers'.[58] It certainly seems that for Hume's followers causal inference can be described as follows: 'given past regularities involving A and B, our minds seem to logically assume when A, then B': A and B, or statements pertaining to them, it seems, are related as a result of a logical deduction (based on past observations).[59] The assumption of something close to a logical necessitation

[58] See, for example, Mackie (1974: 27).
[59] As Hume puts it: 'when by any clear experiment we have discover'd the causes or effects of any phenomenon, we immediately extend our observation to every phenomenon of the same kind'. Hume (1978: 173–4).

seems to be embedded in the Humean, and in most empiricist accounts of causal relation that follow the general Humean assumptions.[60]

This (psycho)'logical' conception of causal connection is important to note because it carries within it a particular form of determinism, so-called regularity-determinism. Basing analysis of causal relations on relations of regularities entails the implicit assumption that, when we account for regularities, we can make causal claims of the form 'given that regularities connect type A and type B events, we have the basis for assuming when A, then B'. Despite Hume's scepticism of relying on inductive inference, his account seems to assume that when regularities are present we come to deduce 'logically' what will happen in a given instance. This assumption has subsequently come to play an important role in Hume's followers' accounts and gives rise to the particular 'closed system', and predictive, view of causation characteristic of twentieth-century approaches to science: given regularities we can logically deduce, or predict, a given event, even if only probabilistically.

Finally, it has to be noted that the Humean discussion of causation takes place strictly within the 'efficient cause' definition of cause marked out by Descartes: 'There is no foundation for [the] distinction ... betwixt efficient causes, and formal, and material ... and final causes. For as our idea of efficiency is deriv'd from the constant conjunction of two objects, wherever this is observ'd, the cause is efficient; and where there is not, there can never be a cause of any kind.'[61] Even though Hume rejects any ontological definition of cause (efficient or otherwise), the efficient cause metaphor plays a crucial role in the Humean accounts. The 'imagined' relation between causes and effects on the basis of regularities is imagined as an efficient one. Indeed, the regularity-deterministic 'given regularities, when A, then B' assumption evidences this well.

These assumptions of Humean philosophy have been widely influential in the philosophy of science in the late nineteenth century and in the twentieth century, as will be seen. However, before moving on to examine Hume's legacy in philosophy of science, it is vital to point to an often-ignored inconsistency in Hume's thought.

[60] Popper, for example, accepts that this is the fundamental contradiction within all empiricist thought (deriving all truths and knowledge from experience but being sceptical of experience as the way to certain knowledge). Popper (1959: 42).

[61] Hume (1978: 171).

Through his scepticist empiricism, Hume is considered to have destroyed any traditional philosophical justification for the concept of cause and for the old metaphysical maxim 'everything must have a cause' – in the ontological 'naturally necessitating' sense.[62] However, the philosophically realist strand of interpretation maintains that Hume does, in contradiction to his empiricist principles, accept the reality of non-observational objects and their causal powers.[63] Some interpreters point to the fact that, although his empiricist philosophical bases dictate that Hume should not talk of 'distinctions between objects and perception', Hume still regularly talks 'of things whereof he should be silent'.[64] In many passages Hume accepts that external (non-perceptual) objects are (ontologically) real and have real unobservable properties, even though we cannot necessarily know them through our ideas or impressions – hence, his frequent references to them as 'the unknown powers'.[65] Hume argues that 'These ultimate springs and principles are totally shut off from human curiosity and enquiry. Elasticity, gravity, cohesion of parts, communication of motion by impulse; these are probably the *ultimate causes and principles* which we shall never discover.'[66]

If metaphysical realism is defined as the belief in a mind-independent ontological reality of the world and its objects,[67] it seems that Hume, in contradiction with his empiricist scepticism, in fact, accepts the ontological nature of reality beyond our knowledge about it.[68] Despite

[62] Wallace (1972b: 40).

[63] The realist interpretation of Hume has a long history. Already some of Hume's contemporaries noticed his realism intertwining with empiricism. More recently, especially John P. Wright has been associated with this strand of interpretation (1983). See also Strawson (1989). An alternative 'projectivist' interpretation is developed in Helen Beebee (2006).

[64] Wallace (1972b: 41).

[65] There are numerous passages that imply this. See, for example, Hume (1978: 159, 267) and (1955: 75, 96).

[66] Hume (1955: 45).

[67] For a more detailed discussion of philosophical realism see chapters 5 and 6.

[68] This implicit metaphysical realism, the philosophically realist interpreters argue, is also evident in Hume's second, often ignored, definition of cause as 'an object precedent and contiguous to another, and so united with it, that the idea of the one determines the mind to form the idea of the other and the impression of the one to form a more lively idea of the other'. Hume (1978: 170). This statement implies that Hume accepts that our minds are 'determined' to pass from one idea or impression to another and that, hence,

arguing that our knowledge is limited to 'constant conjunctions', Hume accepts that causal powers, in a 'metaphysical' sense, still exist beyond our empirical knowledge.[69]

This is a crucial thing to note, not just because it exposes an often-ignored incoherence in the thinking of this supposed 'arch-empiricist', but also because it allows us to realise that perhaps 'heroic Humeanism', with the deficiencies associated with it, is not Hume's position.[70] It follows that we must be cautious in defining Humeanism and in analysing Humean approaches. Humeanism is defined here through the three empiricist assumptions drawn out in this section (regularity, observability and regularity-determinism) and is also seen to be associated with efficient causality (although this does not characterise only Humean approaches). It is argued here that an approach is seen as Humean if it accepts, explicitly or implicitly, these assumptions. However, it is crucial to note that neither Hume himself, nor other scholars, as will be seen, are necessarily 'simply Humean'. This book focuses on drawing out the Humean assumptions in philosophers' and theorists' thinking, but this does not entail that people's views on causation are informed exclusively or coherently by such assumptions. The Humean discourse of causation has, as we shall see, been dominant in modern engagements with causation but its assumptions have played themselves out in various forms – hard and moderate, explicit and implicit – and they have often been accompanied – even if incoherently – with non-Humean assumptions.

The legacy of Humeanism in twentieth-century philosophy of science

The aim of the latter part of this chapter is to inquire into the ways in which Humean assumptions informed the twentieth-century philosophy of science. It is argued that the Humean assumptions have become dominant in how scientific causal explanation is framed. This is because these assumptions – albeit in a variety of forms – have become an essential ingredient of the philosophies of science that dominated twentieth-century philosophy. However, before discussing the legacy

Hume sees imagination and custom (the fundamental basis of his philosophy of causal relation) as real neurological, 'mechanical power' of the human mind. See also Hume (1978: 55, 84–6, 94–5, 104–5, 108).

[69] Hume (1978: 60). [70] Beauchamp and Rosenberg (1981: 32).

of Hume in the twentieth-century philosophy of science, I will first make a brief comment on the first influential philosophical systems to be deeply informed by Hume: Immanual Kant's and John Stuart Mill's.

Kant and Mill

Hume's discussion of causality famously awoke Kant from his 'dogmatic slumber'[71] and precipitated the ambitious Kantian system of philosophy that aimed to synthesise empiricism and rationalism. Hume had argued that causal necessity was but an illusion to which regular experiences gave rise. Kant was disturbed by Hume's sceptical conclusions and sought to give new philosophical grounds for causality. Kant wanted to justify the notion of causal necessity by rooting it in the *a priori* categories of the mind.

For Kant, there are two aspects to knowledge: sensation (passive observation) and thought (spontaneous act of mind). These 'ways of knowing' take place in space and time, intuitions that Kant deduces to be *a priori* categories of the mind.[72] Causality, for Kant, is an important example of an *a priori synthetic* relation that combines both ways of knowing and provides an important justification of human cognition.[73] Kant roots causality in the *a priori* categories of the mind: causal relation is necessary in thought, although not necessary in the world. He justifies causal necessity by arguing that causality is based on the 'necessary intuitions' of space and time that impose necessity on perceptions and thought. He argues that causal relations are 'necessary' because without necessary relation between causes and effects (in thought) experience becomes impossible: causality connects *a priori* categories with experience, thus justifying the role of human cognition.

However, it should be noted that this justification for causation is still squarely within the Humean fold. Although the relation between cause and effect is seen as a 'necessary relation' it is a relation not in the world but in thought. Also, crucially, Kant still sees causality as based on experience, and specifically, on 'the succession of the manifold'.[74] Like Hume's, Kant's conception of causation works on the basis of experienced regular successions: it is still a relation known through

[71] Kant quoted in Ewing (1924: 1). [72] Kant (1993: 48–75).
[73] Kant (1993: 177–80). [74] Kant (1993: 146).

Radical empiricism and the anti-causal turn

For Hume, Kant and Mill, despite the acceptance of some key empiricist assumptions, the notion of cause still played a fundamental role in scientific terminology and knowledge claims. However, at the beginning of the twentieth century there was a distinct turn against the very notion of cause in scientific and philosophical circles, a turn premised on following the Humean assumptions to 'radically empiricist' conclusions.

Ernst Mach was one of the first radical empiricists. Mach based his phenomenalist philosophy on the basic empiricist assumption: 'what is knowable must be perceivable'.[80] However, he took this principle to its extreme logical conclusions: he denied outright the existence of 'things' (external objects) in nature. For Mach, all we can know *and* all that exists are sense-impressions. The job of science is to catalogue these sense-impressions for practical purposes and, hence, all references to 'real objects' and 'external reality' must be abandoned since:

> The world consists only of sensations and the assumption of the nuclei referred to, or of a reciprocal action between them from which sensations proceed, turns out to be quite idle and superfluous. Such a view can only suit a half-hearted realism or a half-hearted philosophical criticism... What I aimed at was merely to obtain a safe and clear philosophical standpoint... shrouded in no metaphysical clouds.[81]

The 'conventionalists' concurred with this anti-realist conclusion. Henri Poincaré and Pierre Dühem proposed that what we think are scientific facts are only what we think are convenient ways of thinking about the world. This entailed a whole-scale rejection of independent reality beyond the human mind, an assumption that had been fundamental for Aristotle and was also implicitly accepted by Hume.[82]

Crucially, the logical positivist philosophers of science who became influential in the early part of the twentieth century followed these empiricist lines of thought: they aimed to give the new radical empiricist premises solid grounding through 'logical analysis of language'. The principle at the heart of logical positivism was Ludwig Wittgenstein's 'verification principle', which maintained that all propositions of

[80] Mach (1959: 46). [81] Mach (1959: 12, 47).
[82] Dantzig (1954: 12). See also Jaki (1984).

science should be analysable by deducing them down to more elementary statements that can be verified through observation.[83] Instead of resorting to tautological analytic statements, such as 'a sleep-inducing powder has dormitive power', or speculative synthetic statements, such as 'all bachelors are drunkards', which are not clearly verifiable, science must base itself on clearly verifiable statements such as 'all observable bodies of the type A, with the observable qualities x, y, z..., tend to, in given circumstances a, b, c..., be observed to behave in C ways', the truth of which can then be clearly established through observation.[84] The logical positivist account of science aims to provide the ultimate bulwark against 'ontological', or 'metaphysical', approaches to science. Indeed, the import of the verification principle was that any non-observation-based statements could be rejected as 'meaningless', since 'we have no idea of what [they are] supposed to signify'.[85]

How did these radical empiricists conceptualise causation? Most radical empiricists interestingly came to abandon all references to causes. Mach and the conventionalists, for example, rejected the notion of cause as an unreliable, rudimentary and 'conventional' notion with no real practical purpose in the new twentieth-century science.[86] The countless controversies in metaphysics seemed to prove that there has never been, nor can there ever be, agreement on the metaphysical question of causation: as a result, it was argued that science had better accept that there is no 'essential' causation.[87] Others, such as Bertrand Russell, similarly concluded that 'the law of causality... like much that passes among philosophers is a relic of a by-gone age'.[88]

On the whole, the issue of causation came to be replaced by a new focus, the analysis of laws, since:

> It is more fruitful to replace the entire discussion of the meaning of causality by an investigation of the various kinds of laws that occur in science. When these laws are studied it is a study of the kinds of causal connections that have been observed. The logical analysis of laws is certainly a clearer, more precise problem than the problem of what causality means.[89]

[83] Wittgenstein (1961). See also Hanfling (1981: 7).
[84] M. Smith (1998: 98–9). See also Ayer (1974: 7).
[85] Schlick quoted in Hanfling (1981: 8).
[86] Poincaré quoted in Dantzig (1954: 93). [87] Wallace (1972b: 168–80).
[88] Bertrand Russell quoted in Wallace (1972b: 181).
[89] Carnap (1966: 204).

The phenomenalist, conventionalist and logical positivist view of science came to be based upon looking for empirical regularities of 'facts', which could (with enough verification, that is, repetition) be inferred into 'general laws'.

Crucially, laws were conceived of in line with Humean assumptions. They were seen as 'factual generalisations', that is, generalisations consisting of observed 'factual' regularities. Since laws were conceived of simply as describing regular patterns of observation, following Hume, causal relations in any deeper 'ontologically necessary' sense were not deemed to concern science. Indeed, the radical empiricists saw references to 'real' causal relations or 'powers' as meaningless. Thus, to say, for example, that 'gravity has causal power' is meaningless because this statement cannot be verified through experience. To talk of such things as gravity meaningfully, we have to construct empirically verifiable statements, such as 'all material bodies with weight X fall to earth', which, when empirically verified (through regular observations), can be inferred to refer to the empirical 'law of gravity'.

This conception of science based on the analysis of laws was, crucially, firmly rooted in the acceptance of the Humean assumptions. Indeed, the radical empiricists acknowledge their roots in Hume and Mill and the tradition of 'English empiricism'.[90] However, they also make clear that what they want to pick up from this tradition is the strictly empiricist premises. They argue that Humean assumptions, when developed coherently, can be used to do away with all the 'vague' discussions of external reality but also, paradoxically, to dispose of the very notion of cause (which Hume, Kant and Mill accepted). The acceptance of Humean assumptions in their pure form, it is pointed out, leads to the obsolescence of the very concept of cause: it is, in fact, a vague notion that must be abandoned in favour of the more precise notion of laws.

It is important to emphasise that although these approaches were largely anti-causal in terminology, they entailed the acceptance of the Humean assumption of regularity-determinism, logical necessity and 'closed systems'. This can clearly be detected in the radical empiricist penchant for talking about 'functional necessitation', 'mathematical functions' and 'prediction', in the place of causation:

[90] Ayer (1974: 73–4).

> The notion of cause possesses significance only as a means of provisional knowledge or orientation. In any exact or profound investigation of an event, the inquirer must regard the phenomena as dependent on one another in the same way that the geometer regards the sides and angles of a triangle as dependent on one another... The concept of cause is replaced... by the concept of function; the determining of the dependence of phenomena on one another, the economic exposition of actual facts, is proclaimed as the object, and physical concepts as a means to an end solely.[91]

While 'functional' and 'mathematical' necessity was not termed 'causal' in the work of these theorists, the emphasis on 'functional determination' and 'mathematical necessity' exemplified the regularity-determinist way of framing relationships of explanatory regularities or laws. When observational regularities have been observed (that is, laws, such as heavy objects fall to the ground), we can deduce predictions from them (that is, when a pen is dropped it will fall). Laws and their relations make up 'closed systems' within which 'when A, then B' type statements can be formulated. The radical empiricists saw the world, and science, as characterised by 'closed systems' where regularities (laws), or statements pertaining to them, were seen as logically related.[92] Within this system causal laws (for example, the causal law of gravity) are conceived as functionally or logically necessitating of outcomes, but they are not conceived as 'naturally' necessitating forces in the world.

It is on the basis of this closed system view of causation that these approaches also emphasised the role of prediction: regularity assumption allows these theorists to talk about not just 'laws' but also predictability.[93] Given that certain regularities, or laws, have been observationally verified, scientists can predict (logically deduce) expected events. Furthermore, the notion of probability is greatly developed as a way of introducing openness to the otherwise regularity-deterministic closed system view of causation. Indeed, the problem of induction (cannot always obtain observationally perfect laws) is solved by resorting to 'probability inferences', that is, probability measurements of the degrees of certainty that an empirical law has (probabilistic theories will be discussed in more detail shortly).[94]

[91] Ernst Mach quoted in Wallace (1972b: 171). See also Mach (1959: 89–92).
[92] See Schlick (1959: 85–7). [93] Carnap (1966: 192).
[94] See, for example, Carnap (1950).

Deductive-nomological causal explanation

From the 1930s onwards the influential logical positivist account of science was challenged 'from within'. What came to replace the dominance of logical positivism in philosophy of science was the 'standard positivism' of Carl Gustav Hempel and Karl Popper. These philosophers of science were ingrained within logical positivism but attacked its excessive reliance on inductive inference. Popper argued that scientific knowledge does not arise simply from inductive observation but, rather, from deductive testing of hypotheses. Popper accepted that scientists hold many theoretical and conceptual (or 'metaphysical') preconceptions before engaging in empirical testing.[95] He also accepted that verification by empirical testing *never* proves conclusively a scientific truth, as the logical positivist view of science had assumed. He maintained that by rejecting the logical positivist inductive view of science in favour of a 'deductive' and 'falsifiability-based' model of science we can justify the practice, rationality and progress of science far more adequately.

Popper argued that the key to a scientific (as opposed to non-scientific) theorising is that it is falsifiable, that any other person can empirically test the theory, and, thereby, either corroborate or falsify it. Science does not need to, nor should it, advance absolute truths: science is about being critical of knowledge claims by subjecting all claims to the possibility of falsification. Popper stipulates that a scientific explanation has to follow a particular method of inference to avoid 'unscientific' and 'unfalsifiable' conclusions. This method of scientific inference is well summarised by Hempel as the so-called 'deductive-nomological' (DN-) model of explanation. The DN- or covering law model claims that the explanatory and predictive logic of science requires that we analyse events (explanandums) through a logically deductive analysis of two kinds of empirical statements, general laws and initial conditions (explanans).[96] Popper argues that 'to give a causal explanation of an event means to deduce a statement which describes it, using as premises of the deduction one or more universal laws, together with certain singular statements, the initial conditions'.[97] This means that to explain something causally we have to describe (a) the universal laws that have been observed (e.g. whenever a weight put on a thread

[95] Popper (1959: 38). [96] Hempel (1966: 50–4). [97] Popper (1959: 59).

exceeds the tensile strength of the thread, it will break), and (b) the initial conditions referring to a particular time and place (e.g. tensile strength of thread X is 1 pound and a weight of 2 pounds is put on the thread); we can then (c) deduce the 'event' to be explained (e.g. the thread breaks).[98]

Contra radical empiricists, Hempel and Popper do not reject the concept of cause. However, it must be noted that the DN-model understanding of science and causality is deeply empiricist and, indeed, Humean. Popper makes it clear that he rejects the metaphysical principle of causation (assumption that everything has an ontological cause), settling, instead, on seeing causal explanations (in the deductive mode prescribed) as a 'guiding methodological rule' of empirical science.[99] Crucially, causal analysis, as a methodological rule, is firmly tied to observation of regular patterns of events. Popper admits that the initial conditions of the deduced event are often referred to as the 'cause' of the event.[100] However, he points out that mere initial conditions *do not* explain: statements of universal causal laws are necessary for any causal explanation. Causal explanation, then, is based squarely on the analysis of regularities. Scientific causal statements require, or more weakly, presuppose, the notion of causal laws (conceived as regularities). Any account that makes a singular causal statement without advancing the laws on which it is presupposed is, as Hempel puts it, only an 'explanatory sketch' that needs to be validated by search for the relevant regularities.[101] To say that placing a weight on a thread was the cause of the thread breaking is only an explanatory sketch that needs validation by laws (observation-based regularities) to qualify as a 'causal explanation'. The general laws are still arrived at through observing regularities of events and the 'general laws' are still the crux of the scientific 'causal' explanation.

Also, the causal statements are still based on regularities of observed events. Science is concerned with generalisations about observations. Hence, 'deep ontological' assumptions about the nature of observables are not necessary for scientific knowledge. For knowledge to be reliable, scientific inquiry must not veer into making unjustifiable speculative claims about unobservables. Popper admits that scientific theories make many theoretical assumptions about unobservables but,

[98] Popper (1959: 60). [99] Popper (1959: 61).
[100] Popper (1959: 60). [101] Hempel (1965: 423).

crucially, emphasises that the confirmation of the plausibility of a scientific account must conform to the logic of the empirical observation specified.[102]

Importantly, it must also be noted that the regularity theory in the DN-model form also entails the assumption of logical necessity and regularity-determinism, that is, if 'laws' have been detected and initial conditions are outlined certain events can be 'logically' deduced. Causal relations refer to logically necessitating relations between statements rather than naturally necessitating causal relationships. The regularity-deterministic assumption is also accepted: it is assumed that 'for every event Y there is an event X, or set of events X1 . . . Xn, such that X, or X1 . . . Xn, and Y are regularly conjoined under some set of descriptions; thus *whenever X (or X1 . . . Xn), then Y*'.[103] Causal explanation and prediction, then, are justified on the basis of a 'closed system' model of causation. Owing to this Humean regularity-deterministic framing of the issue of causation, explanation, prediction and causality come to be seen as mutually dependent, symmetrical processes in the DN-model: causality (understood in terms of regularities) equals explanation equals predictive capability. If prediction is not possible, neither is a scientifically valid causal account nor an explanation of a set of observations.

Probability theories of causation

Popper and Hempel recognised the problem that the strict tying together of 'causality' (conceived of as regularities), prediction and explanation entailed, given how difficult prediction in many sciences is. To deal with this problem of prediction, standard positivism developed the opening for the 'probabilistic' mode of explanation. This mode of explanation works in the same format as the DN-model but

[102] Even though, arguably, the treatment of the notion of cause with Popper acquires some deeply problematic overtones owing to his inability to distinguish between logical and natural necessity and his occasional references to causal laws as 'ontologically' or 'metaphysically' necessary. Indeed, there seems to be an amount of 'slippage' into philosophically realist assumptions in Popper's work, although these sharply contradict his empiricist Humean premises. See Popper (1959: 438). See also essays by Kneale and Popper in Beauchamp (1974c: 36–63).

[103] Bhaskar (1978: 69).

with the requirement of showing probability rather than deductive certainty.[104] Probabilistic explanations are, as Hempel puts it, 'assertions to the effect that if certain specified conditions are realised, then an occurrence of such and such kind will come about with such and such statistical probability'.[105] Here the logic of inference is perhaps best described as 'inductive-probabilistic' in that, rather than being based on 'necessary' deduction from universal laws, it is based on probabilistic hypothesis based on inductively observed frequencies of certain events happening.[106] This model of explanation is still very closely linked to the DN-model, however. As von Wright has summarised, in the probability inferences 'the covering law, the "bridge" or "tie" connecting the basis with the object of explanation, is a probability-hypothesis to the effect that on an occasion when E1 . . . En [initial conditions] are instantiated it is highly probable that E will occur'.[107]

Importantly, a variety of probabilistic theories of causation have prospered in the wake of the DN-model explanation.[108] This is because through the probabilistic mode of inference the empiricist positivist model of science was provided with a useful way of accepting and dealing with uncertainty of knowledge claims: through the probabilistic model we need not make absolutely regularity-deterministic statements necessitated by the ideal of closed system causality. Probability analysis is useful when 'complete causal analysis is not feasible' because of causal complexity or incompleteness of our data or theories.[109]

It is important to remember that the probability models, in the past and in the present debates, are fundamentally tied to the empiricist Humean assumptions of regularity, observability and, indeed, logical regularity-determinism (although in probabilistic form). The resort to probability explanations provides a way for empiricist Humean accounts to recognise – while being premised on a 'closed' model of causality – that perfect prediction and deterministic 'when X, then Y' statements are not always possible.

In many ways the discussions in the burgeoning area of probabilistic causal theorising still focus on the old paradox of empiricist theories of causation: on what grounds may we talk of causal relations when

[104] Hempel (1966: 58–69).
[105] Hempel (2001: 279).
[106] Von Wright (1971: 13–15).
[107] Von Wright (1971: 13).
[108] See, for example, Eells (1991); Suppes (1970); Spirtes, Glymour and Schienes (1999); Hitchcock (1993).
[109] Suppes (1970: 8).

all we can really have knowledge about are observable statistical regularities? How can we derive causal interpretations from statistical data and mathematical forms of knowledge? Contemporary causality and probability modellers recognise that causation does not equal correlation. Nevertheless, it is assumed that statistical methods that measure correlations are what fundamentally give us access to 'causal relations'. What much of the discussion in probabilistic theories of causation is now focused on is discussions of what counts as 'causality' among statistical and mathematical relations and around provision of methods or equations that provide us with what can be described as causal, rather than non-causal, inferences and conclusions.[110]

Implicit legacies of Humeanism

The logical positivist account of science dominated philosophy of science for the first part of the twentieth century. Since the 1950s the Popperian (post)positivist[111] view of science has been dominant, even if criticised with regard to its account of the 'growth of knowledge'. Both versions of the positivist philosophy of science are seen to have been supported by scientific developments in quantum physics and chaos theory. These new areas of science are seen to have demonstrated the uselessness of talking of 'reality' or 'ontological causal powers' and, hence, to have validated the empiricist 'ontologically flat' form of scientific inquiry focused on analysing logical relations of statements and statistical relations of quantifiable variables.[112] It should be noted, however, that the self-evidence of these interpretations is now vehemently contested: it is not clear whether empiricist frameworks have

[110] See especially the discussions surrounding Spirtes, Glymour and Schienes' book *Causation, Prediction and Search* (1999). Interesting discussions can be found in Vaughn R. McKim and Stephen P. Turner's *Causality in Crisis? Statistical Methods and Search for Causal Knowledge* (1997). See also Hausman (1999).

[111] Popper conceived of his own conception of science as postpositivist in relation to logical positivism. However, it is nowadays widely discussed as a variant of a general positivist philosophy of science. See chapter 2 for the definition of positivism applied here.

[112] This assumption has certainly guided the so-called orthodox quantum physics of Heisenberg (1930). See also Born (1949) and Gribbin (1991: 162). Anti-realist interpretations have also been advanced by Quine (1960, 1969).

reflected or contributed to the anti-realist trends in early quantum and chaos theory.[113]

Because of the dominance of empiricist positivist views of science, most philosophy of science debates have, in the past four decades, been debated within the confines of the Humean analysis of causation they have entailed. Humean assumptions have been so dominant that they have, by and large, been accepted as a given in twentieth-century philosophy of science. The debate on the 'growth of knowledge', for example, has been conducted largely within the confines of the Humean assumptions. Although the logical positivist and Popperian models of scientific progress have come under criticism from philosophers such as Thomas Kuhn, Imre Lakatos and Paul Feyerabend,[114] these attacks have not challenged the Humean notion of cause embedded in the positivist accounts of scientific progress.[115]

Because of the largely unproblematised nature of the empiricist positivist views of science, the Humean assumptions, it must be noted, are accepted not just explicitly and knowingly, but increasingly also inadvertently. It is important to point to some of these implicitly Humean legacies in philosophical approaches.

One of the influential theories of causation that has increasingly been adopted by many philosophers of science has been the counterfactual theory of causation. Mill was the first to advance a counterfactual definition of causation but it did not gain wide acceptance until the 1970s when David Lewis developed his counterfactual theory of causation.[116] The counterfactual theory of causation has complicated philosophical justifications involving the 'similarity relations' between possible worlds. The basic idea, however, is simple: E (effect) causally depends on C (cause) if and only if E would not have happened had it not been for C's occurrence. To give a concrete example often utilised by

[113] Recent developments suggest that relativity theory, quantum theory and chaos theory are all commensurable with an ontologically realist and causal approach. See, for example, Fine (1986); Christopher Norris (2000); Bohm and Hiley (1993); Cushing, Fine and Goldstein (1996), Cushing and McMullin (1989); Williams (1997); Bell (1987). See also Bunge (1959, 1979) and Krips (1987).

[114] Lakatos and Musgrave (1970); Kuhn (1962); Feyerabend (1993); Laudan (1978). See also discussion in Chalmers (1996).

[115] Although the empiricist positivist idea of science was questioned by Feyerabend, the empiricist notion of cause, and the attendant form of scientific causal theorising, was never fully attacked. See Feyerabend (1981, 1989).

[116] D. K. Lewis (1973). For revised ideas see D. K. Lewis (1999).

counterfactual accounts: Suzy's throw was a cause of a bottle breaking because, had she not thrown the stone at the bottle, it would not have broken. Essentially this means that causation is defined as a dependency relation between observed events. This assumes an asymmetry between causes and effects, that is, an effect is seen as counterfactually dependent on the cause in a way that the cause is not dependent on the effect.[117] The counterfactual theorists have come up with a variety of 'causal puzzles' to extend and clarify the logic of counterfactual definition of causation.[118] However, for our purposes, it is not necessary to go into these puzzles in great detail; instead what needs to be ascertained is that the counterfactual accounts of causation are often premised on Humean assumptions.

How can Humeanism be seen to play a role in these accounts? First, counterfactual causation of the kind advocated by most philosophers of causation is based squarely on observables: the counterfactual theories analyse the relationships of observed events such as Suzy's throwing of a stone and a bottle breaking. In this sense, these theories conform to the Humean focus on observable events as the focus of causal analysis: they do not touch upon or even claim to investigate the nature of underlying causal powers or mechanisms in science.

Second, their analysis often proceeds on the basis of examining the logical relation between these observed events: the focus is on finding logical patterns in the way in which we assign something as a cause.[119] Counterfactual theory, then, is often conceived of as an epistemological theory: its aim is not to make 'deep ontological' causal claims concerning powers or structures underlying observable instances or events, but to find logical relations between events. This is also seen in the refusal to acknowledge the reality of the theoretical terms used in the discussion. While David Lewis himself was a modal realist with regard to the possible worlds logic that underpins his counterfactual theory of causation,[120] 'most contemporary philosophers . . . would distanc[e] themselves from full-blown realism about possible worlds' and would

[117] For an account of causal asymmetries see Hausman (1998).
[118] See, for example, debates between Lewis and his critics. Collins (2000); D. K. Lewis (2002). See also Collins and Paul (2002).
[119] Hitchcock (2002).
[120] Other theorists such as Peter Menzies (1999) also developed more realist accounts.

'even treat them instrumentally as useful theoretical entities having no independent reality'.[121]

Furthermore, and most interestingly, although counterfactual theories put the focus on singular cases of causal relation, these singular cases often assume a Humean account of laws. Singular claims, as in Mill's account of cause, for example, are based on generalised observational patterns – the breaking of the bottle was counterfactually dependent on Suzy's throw because it is assumed that in the past we have learned through successive observations that when hard objects encounter glass bottles at sufficient speed they tend to break them. As Daniel Hausman's discussion of counterfactuality, for example, evidences, counterfactual theories are discussed in conjunction with a view of causation as 'lawful co-variation', a 'relation fallibly but reliably indicated by correlations and probabilistic dependencies'.[122]

Humeanism of counterfactuality is evidenced also in the fact that counterfactual theories accept a form of regularity-deterministic logic: it is important to note that the 'when no A, no B' logic is but a reversal of the regularity-deterministic deduction 'if A, then B'. Indeed, some philosophers such as Hausman have come to demand that counterfactuality is tied to prediction: 'suppose one accepts a counterfactual of the form, if I were to push the button, the alarm would go off. Such a counterfactual ought to license one to predict that the alarm will go off if one in fact pushes the button.'[123] Much like causality for the DN-model, counterfactual logic for many theorists becomes tied to logical deduction of predictive inferences from known causal regularities.

Another influential account in recent years has been the so-called INUS-condition account developed by J. L. Mackie. A cause for Mackie can usefully be defined as 'an *insufficient* but *non-redundant* [necessary] part of an *unnecessary* but *sufficient* condition'.[124] To give a simple example, what this means is that through the INUS-condition framing we can consider the lighting of a match as a necessary but insufficient element of the background conditions that were unnecessary but together sufficient to produce a result, that is, fire. The INUS-condition account has seemed very appealing to many theorists as it can claim to account for various complexes of causes in a logically coherent manner.

[121] Menzies (2001). [122] Hausman (1996: 62).
[123] Hausman (1996: 64). [124] Mackie (1974: 62).

Interestingly, it has been of particular interest to empiricist and positivist scholars who wish to retain an essentially Humean conception of causation, despite the fact that Mackie himself was not an obvious advocate of empiricist Humeanism, but interested in accounting for causation 'in the world': indeed, he clearly states that causation 'is not merely, as Hume says, *to us*, also *in fact*, the cement of the universe'.[125] What might be interpreted to be Humean about his account?

While Mackie's account suggests that regularities do not exhaust causation in the world, and seems to introduce certain philosophically realist premises (philosophical realism is discussed in more detail in chapter 5) into his overall account, his INUS-condition theory can be interpreted as a descendant of the Humean regularity theory of causation, as a variant of 'modern regularity theory'.[126] First, Mackie's INUS-condition account is both sympathetic to Hume's formulation of causation and compatible with a regularity theory of causation. In many ways it is designed to provide the context for analysis of complex regularities, which is why many empiricists have come to read Mackie's INUS-condition account as an empiricist one: as a 'refinement of the theories of D. Hume and of J. S. Mill'.[127] For a Humean, what is interesting about Mackie's theory is that it can account for more complex conditions of causal regularities, while still allowing us to derive causal statements from regularities of events previously observed. The INUS-condition account has been, for example, used to justify a Humean interpretation of the relationship between cancer and smoking: the theory allows a Humean to call on a regularity relation of smoking and cancer, while still allowing him or her to argue that many other causes (regularity-based intervening variables) have, also, to be accounted for in order to give a 'full account' of INUS-conditions.

Also, it is notable that Mackie's INUS-condition account still eschews accounting for causes in terms of 'deep ontological' causal necessity.[128] In many ways, it could be said that the INUS-condition account, like counterfactual theories of causation, provides a logical structure for how we might characterise causation, rather than an ontological account of causes as producers of outcomes. As will be seen in

[125] Mackie (1974: 2). He accepts realist premises and also a role of natural necessity. Mackie (1974: 215, 228–30).
[126] Beauchamp (1974b: 75).
[127] Horsten and Weber (2005: 955).
[128] A criticism Bhaskar (1979: 207, fn 23) and Patomäki (2002: 76) advance.

chapter 5, however, the application of the INUS-condition idea of cause need not be Humean: it can, when reformulated away from the regularity premise, also be linked to a non-empiricist non-positivist 'deep ontological' conception of causality.

Another aspect of counterfactual and INUS-condition theories of causation is also worth a mention at this point. What is striking about these theories of causation is that they tend to search for a unified language of causality: what they are seeking to do is define a coherent logic for causal statements, such that will apply in all kinds of cases. While specifying the logic of how we should apply the concept of cause in science is of course important, this search for the perfectly formulated singular logic of causation can be seen as problematic in that it presumes that there is a singular logic of causation to be found. Instead of looking for a generally applicable theory of counterfactual causation, perhaps accepting that there might be different kinds of causes and causal conditions, which entail very different kinds of causal intuitions in us, should be recognised more readily in these discussions.[129] This is an issue that will be picked up in chapter 6 as the broadening out of the conceptualisation of the concept of cause is advanced.

Conclusion

The notion of cause has developed significantly over the years. From the broad and ontologically grounded conception of cause, the meaning of the term has been systematically 'narrowed down' in scope to efficient causes, and then 'emptied out' of 'deep ontological' meaning. Hume's empiricist philosophy, in which these two trends culminated, sought to solve the problem of causation by solving the epistemological problem of causation: how do we come to know causes? By arguing that all we have to base causal claims on is observational empirical regularities, Hume assumed that he had provided solid foundations for thinking about causation. The key assumptions that characterise the Humean approach to causal analysis have been identified here as follows.

[129] An example of a positive step in current theories of causation is Cartwright's recent work (2004, 2007) which holds open the possibility of pluralistic theories of causation.

1 Causal relations are tied to *regularities*, and causal analysis to observation of regular patterns.
2 Causal relations are seen as regularity-relations of patterns of *observables*. Statements concerning 'causal ontology' or 'causal powers' are, as unobservable, taken to be meaningless.
3 Causal relations are characterised by *regularity-determinism*: it is assumed that, given certain observed regularities, when A type of events take place, B type of events can be assumed logically to follow. Humeanism, especially in the twentieth century, is based on the assumption of logical necessitation, that is, a 'closed system' view of causation that gives grounds also for prediction.
4 Beyond these strictly Humean assumptions, causes have been understood through the notion of *efficient cause*. Causes are 'moving' causes that 'push and pull'.

These assumptions have become widely accepted in twentieth-century philosophy of science. They were first appealed to by the radical empiricists who turned the discussion of causality into the analysis of the logical relations between observation-based laws. The Popper–Hempel DN-model moderated the excesses of the logical positivist view of science. However, the Humean assumptions have informed the DN-model of scientific explanation, too. Causal explanation has been tied to regularity analysis of observables and is seen to be characterised by regularity-deterministic rather than ontological 'natural' causal necessity.

Crucially, the Humean assumptions have coincided with, and reinforced, a particular conception of science, that is, the empiricist positivist conceptions of science that sees science as defined by 'a scientific method' based on 'systematic' empirical observation. Positivist philosophies of science, informed strongly by empiricist epistemology, consider science as a provider of knowledge that, based as it is on empirical observation of general patterns, provides 'truth-approximating', predictive knowledge of the empirical world around us. The Humean conception of causation, and of science, has become widely accepted as 'self-evident' in much of the philosophy of science and has formed the implicit and unquestioned backdrop for most debates in the philosophy of science in past decades. Indeed, even when it is stated that 'moisture is the cause of the rusting of the knife' or that 'had Suzy not thrown the rock the glass would not have broken', it is accepted that

this 'loose' causal talk is always premised, even if implicitly, on the Humean assumptions (past experiences prove that exposing metal to moisture is followed by appearance of rust; Suzy's throw takes place in the context of regular patterns that make up natural laws). This is because it is accepted that, outside the Humean criteria, there is no meaning to the concept of cause.[130] So internalised has the Humean idea of cause become that the idea of causal analysis has quite simply become equated with adherence to Humean assumptions in one form or another.

This philosophy of cause, however, presents but one philosophical approach to causal analysis among many. The goal of this book is to argue that the Humean solution to the problem of causation is not self-evident in framing causation and causal explanation. This book will seek to draw on theories of causation that, as a consequence of the dominance of Humeanism, have been largely marginalised in the philosophy of science but that, nevertheless, provide consistent and fruitful views on causation and causal analysis. However, before moving on to discuss the philosophical alternatives to Humeanism, the following chapters will concentrate on examining the consequences of the dominance of the Humean framing of causation in the philosophy of social science and in the discipline of International Relations.

[130] Bas Van Fraassen (1980: 113–15) has, in fact, pointed out that empiricists must be careful in using 'loose' causal language because it opens up their accounts to critiques from the scientific realists.