CHAPTER 1

The Nature of Explanation

In our daily lives, the practice of giving explanations is ubiquitous; we often want to explain or obtain an explanation for certain events we encounter. Using more formal language, "explanandum" refers to the event to be explained while "explanans" refers to that which does the explaining. The example of deaths (explanandum) following Covid-19 vaccination (a possible explanans) mentioned in the Preface belongs to the domain of scientific explanations, which this book focuses on.[1] Yet there are explanations that fall outside this domain; one example might be an explanation for why our friend, Mary, got married last year. Scientific explanations and explanations in everyday life appear to be distinct. The former tend to be more objective, systematic, precise and rigorous than the latter, but the distinction may be more apparent than real. This notwithstanding, explanation should be a unified notion in the sense that explanations in everyday life are more or less continuous with scientific explanations (McCain 2015); that is, the differences between the two types of explanation are a matter of degree rather than a distinction in kind (Woodward 2003) and "no argument has ever proved that the logic of explanation in everyday life differs from that of explanation in science" (Faye 1999: 61). In response to a query about her recent marriage, Mary may reply, "I was already thirty years old last year. As you know, in our society, people expect a woman to settle down around that age." Mary's casual everyday-life explanation contains an implicit scientific flavor, revealing a first-person reaction to a social norm concerning the socially desirable marital age for women. Her explanation points to a legitimate research topic in sociology, psychology, or even anthropology. It goes without saying that the structure and very nature of explanations may depend on the explanandum (i.e., what sort of thing is being explained) (Wilson and Keil 1998); explaining why Mary got married last year is very different from explaining why the Hunga Tonga-Hunga Ha'apai volcano

erupted in January 2022 or why a jetliner of China Eastern Airlines crashed on March 21, 2022, resulting in 132 deaths.

Explanations, whether scientific or otherwise, are answers to why-questions, as put forward forcefully by Hempel and Oppenheim (1948: 135):[2]

> To explain the phenomena in the world of our experience, to answer the question "why?" rather than only the question "what?", is one of the foremost objectives of all rational inquiry; and especially, scientific research in its various branches strives to go beyond a mere description of its subject matter by providing an explanation of the phenomena it investigates.

The act of explaining should be distinguished from explanation. Explaining is an action that we take to communicate verbally or non-verbally an explanation to others (McCain 2015), while an explanation is "something one grasps or understands that makes things more intelligible" (Harman 1986: 67). Here the thing we grasp refers to a set of propositions; that is, "an explanation is a set of propositions with a certain structure" (Strevens 2013: 510). According to this view, explanations assume the form of arguments. Put simply, when we explain, we communicate verbally or non-verbally a set of propositions to others. As such, explaining is an intentional act of communication bounded by context, directed at the questioner and potentially persuasive (Faye 1999). This view of explanation belongs to the epistemic conception of explanation discussed in the next section.

The Epistemic versus Ontic Conception of Explanation

In the second half of the twentieth century, philosophers of science set for themselves the task of answering questions related to the nature of explanation, such as "What are the essential features of an explanation?" or "Do different science disciplines have different methods of explaining their research results?" Although the twentieth century closed with no real consensus on the nature of explanation, at the very least, most philosophers of science presumed that explanations belong to a special class of representations (Wright and van Eck 2018). A typical example is Hempel and Oppenheim's (1948: 136–137) description of the relationship between the explanandum and the explanans: "By the explanandum, we understand the sentence describing the phenomenon to be explained (not that phenomenon itself); by the explanans, the class of those sentences which are adduced to account for the phenomenon." Providing an explanation is an attempt to account for a phenomenon and such an account

necessarily represents matters in a certain way but not in another way. In other words, explanations explain by subsuming a phenomenon under a general representation.

The above is essentially the epistemic conception of explanation, according to which "explanations are complexes of representations of entities in the physical world" (Wright and van Eck 2018: 998). Explanation is concerned with understanding and the cognitive abilities of human beings. Ruben (1990: 6) argues that "the analysis of explanation belongs to general epistemology, in the same way as the analysis of knowledge does, and not just to the philosophy of science, narrowly conceived. Scientific explanation, like scientific knowledge, has a special importance and pride of place in a general theory of knowledge." Scientific explanations are texts or descriptions that aim to increase our knowledge about phenomena. For the epistemic conception, it is the text or description that explains (Illari 2013).

At the beginning of the twenty-first century, some philosophers of science challenged the epistemic conception by proposing the ontic conception, according to which "the term *explanation* denotes a class of non-representational, mind-independent entities that are located within reality among its other extant spatiotemporal parts" (Wright 2015: 20). The key difference between the two conceptions concerns "whether explanations are representations of entities in the world or the worldly entities so represented" (Wright and van Eck 2018: 1001). Instead of being representations, ontic explanations are physical entities that reside and participate in the causal structure of the world. In his study of how the brain functions, Craver (2007: 27) provides a definitive description of the ontic conception:

> the term explanation refers to an objective portion of the causal structure of the world, to the set of factors that bring about or sustain a phenomenon (call them objective explanations) . . .. Objective explanations are not texts; they are full-bodied things. They are facts, not representations. They are the kinds of things that are discovered and described. There is no question of objective explanations being "right" or "wrong," or "good" or "bad." They just are.

Mechanismic explanation, which is discussed in Chapter 3, has become the key battlefield where the debate between the epistemic conception and the ontic conception is located. For proponents of the epistemic conception, "since explanation is itself an epistemic activity, what figures in it are not the mechanisms in the world, but representations of them"

(Bechtel 2005: 425). In contrast, the ontic conception maintains that "mechanisms explain the phenomena they explain by being responsible for them" (Illari and Williamson 2011: 821). As such, the mechanisms involved in an explanation might sometimes be beyond our cognitive capacity to comprehend.

Following most philosophers of science, in this book I adopt the epistemic conception of explanation. In addition to the fact that "explanation has traditionally been taken to be squarely in the realm of epistemology" (Humphreys 1989: 3), there are some problems with the ontic conception. For instance, since explanations are a portion of the mind-independent causal structure of the world, explanations do not have any unnecessary or irrelevant parts and "scientists can discover, dissect, disrupt, depict, and describe — but, ironically, not explain" (Wright 2015: 20–21). Since explanations are not arguments, multiple competing good or bad explanations for a given phenomenon do not exist (Waskan 2006). Finally, the ontic conception focuses on the occurrence of an event "explained" by a singular causal interaction (Wright and van Eck 2018). Salmon (1975), however, argues that explanations of particular events seldom have genuine scientific import (as opposed to practical value) and that explanations which deserve serious attention are almost always explanations of categories of events.

The Influence of Ontology

The debate between the epistemic conception and the ontic conception is concerned with the ontological nature of explanation. Ontology in fact also affects how one explains certain phenomena. The current heated debate concerning entrepreneurial opportunities is an excellent illustration. In our daily conversations, a business opportunity is something that can be identified, spotted, seen, seized, or discovered, as shown in the following passage from a *Forbes* article written by the CEO and founder of a technology company dedicated to simplifying digital security for consumers: "Endless business opportunities await those who can spot the openings. Think about the challenges you have faced, services you use regularly and the frustrations you might have had. You might just identify your next big opportunity" (Ravichandran 2021). When an entrepreneur is asked why she set up a new company, a standard answer is something like, "I just discovered an opportunity to provide a new product (or service) that serves a certain market niche." The validity of the explanation hinges on whether an opportunity is something that can be discovered,

leading to the question: "In what mode does an opportunity exist?" This is squarely an ontological problem.

The debate concerning the ontological nature of entrepreneurial opportunities was initiated more than two decades ago by Shane and Venkataraman's (2000) seminal paper "The Promise of Entrepreneurship as a Field of Research," in which they maintained that the defining feature of entrepreneurial phenomena is "the discovery and exploitation of profitable opportunities" (217) and that the objective existence of entrepreneurial opportunities offers a solid foundation for entrepreneurship as a distinctive subject of study. They defined entrepreneurial opportunities as "those situations in which new goods, services, raw materials, and organizing methods can be introduced and sold at greater than their cost of production" (220). That is, entrepreneurial opportunities have to be profitable, in line with people's usual conception of business opportunities. After all, it is nonsensical to say that one has discovered (or created) an opportunity to lose money.[3]

This discovery view of opportunities has been challenged increasingly by scholars expressing their dissatisfaction with the idea that opportunities exist objectively "out there" in ways visible to potential entrepreneurs (McMullen et al. 2007; Davidsson and Wiklund 2009; Alvarez et al. 2014). Challenging the ontological shallowness of Shane and Venkataraman's conceptualization, Görling and Rehn (2008: 101) commented that "opportunities are assumed to simply exist . . . without any real clarity as to what this would mean." Some scholars even denied categorically that opportunities are preexisting entities in the external world, arguing that opportunities are created endogenously through entrepreneurial agency (Wood and McKinley 2010; Korsgaard 2011). The core idea is that "opportunities do not exist until entrepreneurs create them through a process of enactment" (Alvarez et al. 2013: 307). This creation approach places more emphasis on human agency in entrepreneurial activities.

Both the discovery and the creation approaches have obvious fatal flaws. In the case of the former, suppose that a business executive claims to have discovered an entrepreneurial opportunity and then exploits it by establishing a new company. Since the opportunity, by definition, must be profitable, this profitability attribute of the outcome is known with certainty at the moment of "discovery" even before the exercise of entrepreneurial action during exploitation (Ramoglou and Tsang 2016). This is an impossible situation. However, the creation approach does not fare any better. The statement that "opportunities do not exist until entrepreneurs create

them through a process of enactment" (Alvarez et al. 2013: 307) is a universal statement. As such, a single counter-example is good enough to overturn the statement. In fact, one can easily think of many cases where the business opportunity was not created by the entrepreneur but emerged from certain structural changes in the economy. For instance, although many businesses were hit hard by the Covid-19 pandemic, some new business opportunities did emerge because of the structural changes brought about by the pandemic (Colvin 2020). Alvarez et al. (2013) may abandon the universal statement and concede that some opportunities are created whereas others aren't. Yet this is anything but a solution because they will then face the uphill task of distinguishing clearly between these two types of opportunities and delineating their relationship, as well as dealing with the fatal flaws associated with the discovery approach (Ramoglou and Tsang 2017).

As a remedy, Stratos Ramoglou and I proposed the actualization approach. Based on a realist philosophy of science, we rehabilitated ontologically the objectivity of entrepreneurial opportunities by elucidating their propensity mode of existence. We defined entrepreneurial opportunity as "the propensity of market demand to be actualized into profits through the introduction of novel products or services" (Ramoglou and Tsang 2016: 411). Opportunities exist akin to a flower seed's propensity to germinate into a flower versus the flower itself. There are three ways individuals might have cognitive contact with opportunities: (1) imagining the state of the world where one makes profits by engaging in an entrepreneurial course of action; (2) believing that this state of the world is ontologically possible; and (3) after the realization of profits, knowing retrospectively that the opportunity in question was truly there. That is to say, the only occasion where we can know the existence of an opportunity is at the realization of profits; in the case of failure, we are agnostic. Our approach provides an intuitive and paradox-free understanding of what it means for opportunities to exist objectively.

The fatal flaws of the discovery and creation approaches are also reflected in the different explanatory efficacies of the three approaches. This can be illustrated by the case of Theranos – a high-flying but ultimately failed biotech start-up that promised to revolutionize blood testing by inexpensively performing dozens of tests based on a single finger-prick. Theranos is said to have been Silicon Valley's greatest disaster in recent years. The trial of Theranos's former CEO and founder, Elizabeth Holmes, ended in early January 2022 and drew a great deal of media attention; Holmes was found guilty on four charges of defrauding

investors. Let's conduct a thought experiment. Rewind to 2013 when Theranos was at its peak, valued at about US$9 billion, with Holmes not only an entrepreneur but also a celebrity. Suppose that in an entrepreneurship course, a student asks the professor somewhat naively, "Why did Elizabeth Holmes establish Theranos?" How would the professor reply?

If the professor is a follower of the discovery approach, he would probably reply, "Holmes discovered a business opportunity that will revolutionize blood testing. She set up Theranos to exploit the opportunity." If he subscribes to the creation approach, his answer would be something like: "Holmes created an opportunity to revolutionize blood testing and is exploiting the opportunity through Theranos." With the benefit of hindsight, both answers are problematic. Given the current state of blood testing technology, it can be concluded safely that the entrepreneurial opportunity that Holmes came up with simply didn't and still doesn't exist. Since the opportunity never existed, there was nothing to be discovered, period. As to the creation-based answer, it was simply impossible for Holmes to have created the so-called opportunity. Note that an entrepreneurial opportunity has to be profitable and, in this case, the opportunity in question could not be profitable. Rather, what she had in fact created was Theranos, nothing more, nothing less.

If the professor buys our argument that opportunities exist objectively as propensities, he would have replied, "Since Theranos hasn't been profitable, we are not sure whether Holmes's *imagined* business opportunity exists. At this moment, what we can say is only that she seems to *believe* that the opportunity does exist and so established Theranos to exploit it." In 2015, John Carreyrou, who at that time was working for the *Wall Street Journal*, began writing a series of investigative articles on Theranos that questioned the firm's blood testing claims and exposed its alleged fraudulent activities. His book, *Bad Blood: Secrets and Lies in a Silicon Valley Startup*, provides a detailed account of the Theranos case. The book, as well as media reports of the case, indicate that Holmes's coming up with the idea of performing dozens of blood tests based on a single fingerprick and her belief that her idea would work are consistent with the first two ways of cognitive contact with opportunities, namely, imagining and believing. (It's just that in this case, her imagined opportunity did not exist.) Holmes had little relevant technical knowledge when she conjured up her revolutionary idea of blood testing. It is not an exaggeration to say that her idea was born out of passion and pure imagination:

> She quoted Jane Austen by heart and referred to a letter that she had written to her father when she was nine years old insisting, "What I really want out of life is to discover something new, something that mankind didn't know was possible to do." And it was this instinct, she said, coupled with a childhood fear of needles, that led her to come up with her revolutionary company. (Bilton 2016)

Despite her idea lacking any scientific foundation, the following description indicates Holmes's strong belief in the idea's feasibility:

> Phyllis Gardner, an expert in clinical pharmacology at Stanford, recalled discussing Holmes's skin patch idea and telling her it "wouldn't work."
>
> "She just stared through me," Dr Gardner told the BBC.
>
> "And she just seemed absolutely confident of her own brilliance. She wasn't interested in my expertise and it was upsetting." (Thomas 2022)

Such a belief propelled Holmes through the obstacles encountered in growing Theranos until its fraud was exposed by people like Carreyrou. In brief, the actualization approach provides the best answer to the student's why-question in 2013 without the benefit of hindsight.

Explanation involves relationships between entities. As demonstrated by the above example, ontology plays a significant role when an entity's mode of existence is ambiguous. Such ambiguities are not rare in the social sciences, given the complexity of social ontology, which are concerned with the reality of money, government, property, marriage and so on (Searle 2006).

Understanding

The above distinction between explaining and explanation can also be framed in cognitive terms. Explaining is a cognitive process that, when carried out successfully by the initiator, yields a particular cognitive outcome – explanation – that in turn promotes understanding (McCain 2015) and is sometimes accompanied by an "aha" feeling or "Eureka!" moment. Wilkenfeld (2014: 3368) argues that "explanations just ARE those sorts of things that, under the right circumstances and in the right sort of way, bring about understanding." In other words, an explanation must be capable of "making clear something not previously clear" (Scriven 1962: 175), or "relating (or reducing) unfamiliar phenomena to familiar ones" (Friedman 1974: 9). Metaphorically describing the distinctive cognitive experience of explanatory understanding, Peirce (1908: 100) says that a good explanation "is turned back and forth like a key in a lock."

Since a phenomenon is inextricably bound up with others, a given explanation usually has implications for phenomena associated with the one it initially attempts to explain. Therefore, explanation increases understanding not just for its target but also for a larger domain of related affairs (Wilson and Keil 1998). Explanation is like detective work, in which the researcher meticulously pieces together otherwise disparate facts into a coherent, understandable picture.

To understand why an event occurs is a cognitive achievement greater than simply knowing that the event occurs (Lipton 2009). For example, in early 2010, there was news reporting that Toyota had recalled millions of vehicles in the United States. Knowing that this event had occurred is one thing; understanding why it occurred is another. Here, it is useful to distinguish between description and explanation. Put simply, "description tells us what is there, explanation why it is there" (Bergmann 1957: 79). News reporting provided a description of the Toyota recall, usually with an explanation: the recall was due to a problem with the gas pedal. This explanation promoted understanding of the event, leading to a greater epistemic gain than simply knowing of its occurrence through reading the related description.

Another example is in natural science. Robert Brown in 1827 discovered the continuous movement of small particles suspended in a fluid. He announced the following year this discovery – later termed Brownian motion – only by describing it. At the close of the century, Gouy's research convinced him that Brownian motion was a clear demonstration of the existence of molecules in continuous movement. Nevertheless, he failed to work out any mathematized theory that could be subjected to quantitative confirmation or falsification. In 1905, Einstein formulated the mathematical laws governing the movements of particles based on the principles of kinetic-molecular theory, thus providing an explanation for Brownian motion (Maiocchi 1990). The explanation renders the movement of such small particles intelligible. This is why understanding is said to be "a mental state with positive epistemic status" (McCain 2015: 833).

An explanation "fills in a particular gap in the understanding of the person or people to whom the explanation is directed" (Scriven 1962: 175). As a cognitive achievement, understanding necessitates the exercising of cognitive ability and can be an effortful activity; it "requires the grasping of explanatory and other coherence-making relationships in a large and comprehensive body of information" and "is achieved only when informational items are pieced together by the subject in question"

(Kvanvig 2003: 192). As such, understanding of complicated matters often comes in degrees (Elgin 2007). Suppose that immediately after its massive vehicle recall in 2010, Toyota releases a detailed and rather technical report of the gas pedal problem that explains how that problem was related to the scale of the recall. Individuals' cognitive ability, as reflected in their relevant background knowledge, affects the depth of their understanding promoted by Toyota's explanation. In other words, the same explanation may lead to different degrees of understanding by different individuals. The quality of an explanation is thus audience-relative.

Explanations should be based on facts: we want explanations to be truth-tracking (Faye 1999). However, citing that a fact in question is an instance of a generalization is not an explanation because it provides no additional understanding beyond the generalization (Bunge 1997). Suppose someone asked, "Why did Peter die last month?" The answer "Peter was human and all humans are bound to die eventually" is not an explanation for Peter's death, presuming that we already know Peter was a person. Rather, the answer merely identifies Peter as a member of the human race and so supplies no understanding at all. In contrast, the answer "Peter was hit by a car and died instantly" is a valid explanation, promoting our understanding of his death.

The cognitive sense of understanding is derived from the intellectual satisfaction that a research question has been answered adequately. This sense of satisfaction often increases one's confidence that the related explanation is true; that is, the explanation is an accurate description of the underlying causal factors that bring about the phenomenon in question. A helpful example is Jean Perrin's work on molecules. At the turn of the twentieth century, there was heated debate among scientists about the reality of molecules. Perrin proposed a lucid argument in favor of molecules' existence. His argument was based on the experimental determination of Avogadro's number, N, which is the number of molecules in a mole of any substance. Perrin performed a spectacular set of experiments on Brownian motion of colloidal particles. Using an ultramicroscope, he was able to determine N based on observations of the vertical distribution of these particles in suspension. A number of distinct experimental techniques were developed in the science community to determine N. Perrin counted thirteen different techniques, including those with a basis in Brownian motion, alpha decay, X-ray diffraction, blackbody radiation, or electrochemistry (Jenson 2015). All these methods produced practically the same number, enabling Perrin to comment with confidence